

TEST RESULTS OF LEVEL B SUITS TO CHALLENGE
BY CHEMICAL AND BIOLOGICAL
WARFARE AGENTS AND SIMULANTS:
SUMMARY REPORT

Robert S. Lindsay

April 1999

Approved for public release, distribution is unlimited.

Soldier and Biological Chemical Command
AMSSB-REN, Aberdeen Proving Ground, MD 21010-5424

Disclaimer

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorizing documents.

| | | | | |
|--|---|--|---|--|
| REPORT DOCUMENTATION PAGE | | | <i>Form Approved</i> <i>OMB No. 0704-0188</i> | |
| Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503. | | | | |
| 1. AGENCY USE ONLY (Leave Blank) | | 2. REPORT DATE April 1999 | 3. REPORT TYPE AND DATES COVERED Final; Jan 98 – Jun 98 | |
| 4. TITLE AND SUBTITLE Test Results of Level B Suits to Challenge by Chemical and Biological Warfare Agents and Simulants: Summary report | | | 5. FUNDING NUMBERS None | |
| 6. AUTHOR(S) Lindsay, Robert S. | | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) DIR, ECBC, ATTN: AMSSB-REN-SO, APG, MD 21010-5424 | | | 8. PERFORMING ORGANIZATION REPORT NUMBER ECBC-TR- | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Commander, SBCCOM, ATTN: AMSSB-ODP, APG, MD 21010-5424 | | | 10. SPONSORING/MONITORING AGENCY REPORT NUMBER | |
| 11. SUPPLEMENTARY NOTES | | | | |
| 12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited. | | | 12b. DISTRIBUTION CODE | |
| 13. ABSTRACT (Maximum 200 words) Six Level B protective suits were tested for GB and HD permeation swatch testing using modified procedures of TOP 8-2-501. Agent break-through times were calculated for each suit. Aerosol agent simulant tests of suit systems were also conducted to measure overall protection factors of the suits. | | | | |
| 14. SUBJECT TERMS HD Swatch testing Permeation testing GB Aerosol Testing Chemical protective suits | | | 15. NUMBER OF PAGES | |
| | | | 16. PRICE CODE | |
| 17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED | 18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED | 19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED | 20. LIMITATION OF ABSTRACT UL | |

Blank

Executive Summary

As part of the Domestic Preparedness Program, six Occupational Safety and Health Level B* suit designs were tested to assess their capability to protect in a chemical warfare agent or biological agent environment. Swatches of material from each suit design were tested for resistance to permeation for both Sarin (GB) and mustard agent (HD). From this data the authors calculated the estimated time it would take to permeate the suit with sufficient agent to cause physiological effects in a person wearing the suit. Each suit design was also tested for its protection factor in an aerosol environment (aerosolized corn oil, which may be representative of a chemical or biological agent, was used). Protection factor is defined as the ratio between the challenge concentration outside the suit and the measured concentration inside the suit. The tests are described, and the calculated breakthrough times and overall protection factors are presented.

* Level B protection consists of chemical-resistant clothing (overalls and long-sleeved jacket; hooded one or two piece chemical splash suit; disposable chemical-resistant one-piece suit), inner and outer gloves, chemical-resistant safety boots and hard hat with pressure-demand full-facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA. Level B, rather than Level A, protection is used when a high level of respiratory protection is required but less skin protection is needed.

Blank

Preface

The work described in this report was authorized under the Expert Assistance (Equipment Test) Program for the Soldier and Biological Chemical Command (SBCCOM) Program Director for Domestic Preparedness.

The use of either trade or manufacturers' names in this report does not constitute an official endorsement of any commercial products. This report may not be cited for purposes of advertisement.

This report has been approved for public release. Registered users should request additional copies from the Defense Technical Information Center; unregistered users should direct such requests to the National Technical Information Service.

Acknowledgments

The author acknowledges John Baranoski, Janice Hannigan, Terri Longworth, Marcia Johnson and Alex Pappas for conducting the tests upon which this report is based; Richard Belmonte for his assistance and encouragement; and Frank DiPietro and Anthony Saponaro for managing the equipment acquisition and test scheduling necessary to accomplish the testing in a timely manner.

The author also acknowledges the technical contributions of the Expert Review Panel for Personal Protective Equipment (PPE) Testing:

Dr. Jimmy Perkins, University of Texas School of Public Health, San Antonio, TX.

Dr. Annetta Watson, Life Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Dr. Ted Zellers, University of Michigan School of Public Health, Ann Arbor, MI.

Leo F. Saubier, Battelle Memorial Institute, Edgewood, MD.

The Panel reviewed and commented on the test procedures, instrumentation, data analysis and presentation. Their guidance was a valuable element in the development of clear and adequate descriptions of the concepts and procedures used in these tests.

Blank

CONTENTS

| | | |
|-------|--|----|
| 1. | INTRODUCTION..... | 11 |
| 2. | OBJECTIVES..... | 11 |
| 3. | TESTING AND DATA ANALYSIS..... | 11 |
| 3.1 | TESTING OVERVIEW..... | 11 |
| 3.2 | LIQUID CHALLENGE/VAPOR PENETRATION TESTING (AGENT SWATCH TESTING)..... | 12 |
| 3.2.1 | Liquid Challenge/Vapor Penetration Testing Procedures..... | 12 |
| 3.2.2 | Liquid Challenge/Vapor Penetration Testing Analysis..... | 14 |
| 3.2.3 | Correlation Between Liquid Challenge/Vapor Penetration Test Results and Skin Exposure..... | 14 |
| 3.2.4 | Test Criteria for Liquid Challenge/Vapor Penetration Testing..... | 14 |
| 3.3 | SYSTEM TEST (AEROSOL SIMULANT)..... | 15 |
| 3.3.1 | Aerosol Simulant Test Procedures..... | 15 |
| 3.3.2 | Aerosol Simulant Analysis..... | 15 |
| | ACRONYMS AND ABBREVIATIONS..... | 17 |
| | APPENDIXES | |
| A - | LEVEL B SUITS CHOSEN FOR TESTING..... | 19 |
| B - | MODIFIED STATIC DIFFUSION TEST PROCEDURE..... | 21 |
| C - | AEROSOL SIMULANT TEST PROCEDURE..... | 23 |
| D - | MSA BLUE MAX..... | 25 |
| E - | LAKELAND TYCHEM 9400..... | 31 |
| F - | KAPPLER CPF3..... | 37 |
| G - | MARMAc TYVEK/SARANEX..... | 43 |
| H - | ILC DOVER MODEL 16-51..... | 49 |
| I - | TRELLEBORG SPLASH 700..... | 55 |
| J - | OVERALL TEST RESULTS..... | 61 |

TABLES

| | | |
|------|--|----|
| 1. | WEIGHTING FACTORS FOR EACH SAMPLING AREA BY SUIT | 14 |
| 2. | AGENT BREAKTHROUGH CRITERIA | 15 |
| A-1. | LEVEL B SUITS TESTED | 19 |
| D-1. | MSA BLUE MAX - AVERAGE HD PERMEATION | 26 |
| D-2. | MSA BLUE MAX - AVERAGE GB PERMEATION..... | 27 |
| D-3. | MSA BLUE MAX - SYSTEM TEST (AEROSOL SIMULANT) RESULTS | 30 |
| D-4. | MSA BLUE MAX - OVERALL TEST RESULTS | 30 |
| E-1. | LAKELAND TYCHEM 9400 - AVERAGE HD PERMEATION | 32 |
| E-2. | LAKELAND TYCHEM 9400 - AVERAGE GB PERMEATION | 33 |
| E-3. | LAKELAND TYCHEM 9400 - SYSTEM TEST (AEROSOL SIMULANT) RESULTS | 36 |
| E-4. | LAKELAND TYCHEM 9400 - OVERALL TEST RESULTS..... | 36 |
| F-1. | KAPPLER CPF3 - AVERAGE HD PERMEATION..... | 38 |
| F-2. | KAPPLER CPF3 - AVERAGE GB PERMEATION | 39 |
| F-3. | KAPPLER CPF3 - SYSTEM TEST (AEROSOL SIMULANT) RESULTS | 42 |
| F-4. | KAPPLER CPF3 - OVERALL TEST RESULTS | 42 |
| G-1. | MARMAC TYVEK/SARANEX - AVERAGE HD PERMEATION | 44 |
| G-2. | MARMAC TYVEK/SARANEX - AVERAGE GB PERMEATION | 45 |
| G-3. | MARMAC TYVEK/SARANEX- SYSTEM TEST (AEROSOL SIMULANT) RESULTS..... | 48 |
| G-4. | MARMAC TYVEK/SARANEX - OVERALL TEST RESULTS..... | 48 |
| H-1. | ILC DOVER MODEL 16-51 - AVERAGE HD PERMEATION | 50 |
| H-2. | ILC DOVER MODEL 16-51 - AVERAGE GB PERMEATION..... | 51 |
| H-3. | ILC DOVER MODEL 16-51 - SYSTEM TEST (AEROSOL SIMULANT) RESULTS..... | 54 |
| H-4. | ILC DOVER MODEL 16-51 - OVERALL TEST RESULTS | 54 |
| I-1. | TRELLEBORG SPLASH 700 - AVERAGE HD PERMEATION | 56 |
| I-2. | TRELLEBORG SPLASH 700 - AVERAGE GB PERMEATION | 57 |
| I-3. | TRELLEBORG SPLASH 700 - SYSTEM TEST (AEROSOL SIMULANT) RESULTS | 60 |
| I-4. | TRELLEBORG SPLASH 700 - OVERALL TEST RESULTS..... | 60 |
| J-1. | SUMMARY OF OVERALL RESULTS FOR ALL LEVEL B SUITS..... | 62 |

FIGURES

| | | |
|------|---|----|
| D-1. | MSA BLUE MAX - FRONT VIEW..... | 25 |
| D-2. | MSA BLUE MAX - SIDE VIEW..... | 25 |
| D-3. | MSA BLUE MAX - WEIGHTED AVERAGE HD PERMEATION..... | 28 |
| D-4. | MSA BLUE MAX - WEIGHTED AVERAGE GB PERMEATION..... | 28 |
| D-5. | MSA BLUE MAX: HD PERMEATION BY SAMPLING AREA..... | 29 |
| D-6. | MSA BLUE MAX: GB PERMEATION BY SAMPLING AREA..... | 29 |
| E-1. | LAKELAND TYCHEM 9400 - FRONT VIEW..... | 31 |
| E-2. | LAKELAND TYCHEM 9400 - SIDE VIEW..... | 31 |
| E-3. | LAKELAND TYCHEM 9400 - WEIGHTED AVERAGE HD PERMEATION..... | 34 |
| E-4. | LAKELAND TYCHEM 9400 - WEIGHTED AVERAGE GB PERMEATION..... | 34 |
| E-5. | LAKELAND TYCHEM 9400: HD PERMEATION BY SAMPLING AREA..... | 35 |
| E-6. | LAKELAND TYCHEM 9400: GB PERMEATION BY SAMPLING AREA..... | 35 |
| F-1. | KAPPLER CPF3 - FRONT VIEW..... | 37 |
| F-2. | KAPPLER CPF3 - SIDE VIEW..... | 37 |
| F-3. | KAPPLER CPF3 - WEIGHTED AVERAGE HD PERMEATION..... | 40 |
| F-4. | KAPPLER CPF3 - WEIGHTED AVERAGE GB PERMEATION..... | 40 |
| F-5. | KAPPLER CPF3: HD PERMEATION BY SAMPLING AREA..... | 41 |
| F-6. | KAPPLER CPF3: GB PERMEATION BY SAMPLING AREA..... | 41 |
| G-1. | MARMAC TYVEK/SARANEX - FRONT VIEW..... | 43 |
| G-2. | MARMAC TYVEK/SARANEX - SIDE VIEW..... | 43 |
| G-3. | MARMAC TYVEK/SARANEX- WEIGHTED AVERAGE HD PERMEATION..... | 46 |
| G-4. | MARMAC TYVEK/SARANEX - WEIGHTED AVERAGE GB PERMEATION..... | 46 |
| G-5. | MARMAC TYVEK/SARANEX - HD PERMEATION BY SAMPLING AREA..... | 47 |
| G-6. | MARMAC TYVEK/SARANEX - GB PERMEATION BY SAMPLING AREA..... | 47 |
| H-1. | ILC DOVER MODEL 16-51- FRONT VIEW..... | 49 |
| H-2. | ILC DOVER MODEL 16-51- SIDE VIEW..... | 49 |
| H-3. | ILC DOVER MODEL 16-51 - WEIGHTED AVERAGE HD PERMEATION..... | 52 |
| H-4. | ILC DOVER MODEL 16-51 - WEIGHTED AVERAGE GB PERMEATION..... | 52 |
| H-5. | ILC DOVER MODEL 16-51: HD PERMEATION BY SAMPLING AREA..... | 53 |
| H-6. | ILC DOVER MODEL 16-51: GB PERMEATION BY SAMPLING AREA..... | 53 |
| I-1. | TRELLEBORG SPLASH 700 – FRONT VIEW..... | 55 |
| I-2. | TRELLEBORG SPLASH 700 - SIDE VIEW..... | 55 |
| I-3. | TRELLEBORG SPLASH 700 - WEIGHTED AVERAGE HD PERMEATION..... | 58 |
| I-4. | TRELLEBORG SPLASH 700 - WEIGHTED AVERAGE GB PERMEATION..... | 58 |
| I-5. | TRELLEBORG SPLASH 700: HD PERMEATION BY SAMPLING AREA..... | 59 |
| I-6. | TRELLEBORG SPLASH 700: GB PERMEATION BY SAMPLING AREA..... | 59 |
| J-1. | WEIGHTED AVERAGE HD PERMEATION..... | 61 |
| J-2. | WEIGHTED AVERAGE GB PERMEATION..... | 61 |

Blank

TEST RESULTS OF LEVEL B SUITS TO CHALLENGE BY CHEMICAL AND BIOLOGICAL WARFARE AGENTS AND SIMULANTS: SUMMARY REPORT

1. INTRODUCTION

In 1996, Congress passed Public Law 104-201 (Defense Against Weapons of Mass Destruction Act of 1996), directing the Department of Defense (DoD) to assist other federal, state and local agencies in enhancing preparedness for terrorist attacks using weapons of mass destruction. DoD responded by forming the Domestic Preparedness Program that same year. One of the objectives of the Domestic Preparedness Program is to enhance emergency and hazardous material response to Nuclear, Biological and Chemical (NBC) terrorism incidents. As part of an effective response, people who are responding to an incident will use personal protective equipment to protect them from exposure to chemical agents or biological agents. The specific personal protective equipment that will be used depends upon the situation that they encounter and what they have on hand. In some cases, Level B protective suits may be required to enter a contaminated or potentially contaminated area. Level B suits are chemical-resistant clothing that protect the wearer from liquid chemicals. Air is supplied by a pressure-demand full-facepiece Self-Contained Breathing Apparatus (SCBA) or pressure-demand supplied-air respirator with escape SCBA.

2. OBJECTIVES

This study evaluates some commonly used Occupational Safety and Health Administration (OSHA) Level B suits to assess how well they resist vapor permeation from liquid contamination¹ by chemical agents GB and HD and droplet penetration by a corn-oil aerosol used to simulate biological or chemical particulates greater than 0.4 microns in diameter. All references to Level B suits in this report refer to OSHA Level B suits. This information is intended for emergency responders as an aid in evaluating Level B suits when they choose to include military chemical and biological agent protection as a criterion. The information supplements data and information provided by the suits' manufacturers. The suits are tested in new, as-received condition. The effects of aging, temperature extremes, laundering, and other factors are beyond the intended scope of this test program. These tests are conducted to assess percutaneous protection only².

3. TESTING AND DATA ANALYSIS

3.1 Testing Overview.

Appendix A has a list of the Level B suits that are tested in this test program. Testing Level B suits includes a permeation test of material swatches to measure the permeation of both Sarin (GB) and Mustard (HD) through the swatches. System tests are also conducted to measure

¹ Throughout this report the term permeation is used even though for some of the tests the precise mechanism of agent transfer is not determined and penetration is likely to be involved also.

² Inhalation and ocular protection are typically provided by the use of a self-contained breathing apparatus or air-supplied respirator that covers the eyes, nose and mouth.

the total aerosol leakage into the suits, when people, as part of a complete personal protective equipment (PPE) system wear them.

3.2 Liquid Challenge/Vapor Penetration Testing (Agent Swatch Testing)

3.2.1 Liquid Challenge/Vapor Penetration Testing Procedures.

This testing is conducted to measure the actual permeation of chemical agents GB and HD through suit swatches over a 24-hour period. The test is intended to assess how well the suit materials and interfaces resist agent permeation. The amount of agent applied and duration of exposure do not represent any particular threat that responders may encounter, but they do serve as a common point of reference for all test results.

The test methodology was taken from TOP 8-2-501³ and is described in appendix B. Three swatches are taken from each of six different areas of the suit – 18 total swatches per suit design for GB and 18 more for HD. In addition an indicator swatch is taken from a silicone rubber (M45 mask formulation) slab and used as a positive indication of agent permeation. Each of the three swatches is placed in a test cell (six material swatches per test and one indicator swatch). Laboratory personnel apply a predetermined liquid agent challenge (10 g/m² – a very severe challenge in the author’s opinion) to the top surface of each swatch. Agent droplets are applied to the surface of the first swatch at time zero. Agent is then applied to the surface of each succeeding swatch at 3-minute intervals. The upper chamber of each test cell is sealed and a 1.0 liter/minute flow of air, from the test chamber, is maintained in the lower test cell chamber beneath each swatch.

During the 24-hour test period, gas samples are taken on a sequential basis by a laboratory MINICAMS (OI Analytical, CMS Field Products Group, Birmingham, AL) with stream selection system (a miniaturized gas chromatograph with flame photometric detector and sampling system) from the airstream beneath each swatch. Gas sampling by the MINICAMS begins for the first swatch approximately 3 minutes following agent application. Subsequent 3-minute cycles of the MINICAMS are composed of 2 minutes of desorption of collected agent vapor from the pre-concentrator tube (PCT) onto the column followed by 1 minute of gas sampling (collection of agent vapor in the PCT). Sampling is done sequentially through six swatches (3 from one sampling area followed by 3 from a second sampling area), the silicone indicator⁴ and then three blank gas samples are taken from the test chamber to purge the sampling line prior to beginning the sampling sequence again. The six swatches, the indicator swatch, and three blanks are all sampled for the first time within the first 30 minutes of the test. Then the sampling sequence begins anew.

The MINICAMS first determines the amount of agent vapor in each gas sample. Using this result, the amount (nanograms) of agent vapor present in the airstream that passes beneath

³ Test Operations Procedure (TOP) 8-2-501, Permeation and Penetration of Air-Permeable, Semipermeable and Impermeable Materials with Chemical Agents or Simulants (Swatch Testing). U.S. Dugway Proving Ground, UT. 3 March 1997, UNCLASSIFIED Report (ADA322329).

⁴ The silicone indicator swatch was originally intended to serve as a positive control. Due to budgetary and schedule limitations, the management decision was made to use 80-mil silicone as a positive indication of agent permeation only.

the swatch over the time from the previous gas sample to the current gas sample is determined by the MINICAMS permeation software. This amount of agent vapor is presumed to be the amount of agent vapor that has permeated the swatch over that time interval. Given the area of the test swatch, the MINICAMS permeation software determines the M_f at each elapsed time for each swatch. Over the 24-hour test period, a series of M_f values is calculated for each swatch. M_f is defined as the cumulative mass of agent permeating the swatch per unit area at any elapsed time during the 24-hour test.

3.2.2 Liquid Challenge/Vapor Penetration Testing Analysis.

Each suit has M_f data for 18 swatches (only 15 swatches for the MSA Blue Max because there were only five different sampling areas available) for each of the two agents over the 24-hour test period. M_f data are taken for each of the three swatches from one sampling area tested with one of the agents. For this report, the average (of three swatches) cumulative permeation (M_f) is calculated. This average is then presented, at each of the reported elapsed times, as representative of the suit's permeation resistance at that sampling area. The reported elapsed time for each sampling area is the sum of the elapsed times for the three swatches divided by three. For each suit tested, swatches were taken from a single suit.

To estimate M_f at each elapsed time for a suit, the simplifying assumption is that the exposure is uniform over the entire suit. This permits the use of the weighting factor scheme developed by Richard Belmonte⁵ to determine the weighted average M_f at each average elapsed time. The average elapsed time is the sum of the reported elapsed times for all the sampling areas divided by the number of sampling areas. The weighting factors shown in Table 1 were assigned roughly on the basis of surface area assigning a minimal value of 5%. Swatches were not necessarily taken from exactly the same locations for all suits since their configurations differed. The weighted average M_f at any average elapsed time is calculated using an equation similar to the following (using the TYCHEM 9400 weighting factors for this example):

Weighted average $M_f = 0.5(\text{suit material } M_f) + 0.15(\text{seam material } M_f) + 0.05(\text{boot material } M_f) + 0.15(\text{boot material } M_f) + 0.1(\text{crotch area } M_f) + 0.05(\text{zipper/material interface } M_f)$

⁵ Belmonte, R.B., *Test Results of Level A Suits to Challenge by Chemical and Biological Warfare Agents and Simulants: Summary Report*, ERDEC-TR-513, U.S. Army Edgewood Research, Development and Engineering Center, Aberdeen Proving Ground, MD, August 1998, UNCLASSIFIED Report (ADA353013).

Table 1. Weighting Factors For Each Sampling Area by Suit

| Suit Model | Weighting Factor, Percent, for Each Sampling Area | | | | | | | | | | |
|---------------------------------------|---|-------------|---------------|-------------------|----------------|-----------------------|-----------|--------------|---------------|---------------|---------------------------|
| | Suit Material | Crotch Area | Seam Material | Visor/Gasket Seam | Glove Material | Visor/Gasket Material | Boot Seam | Outer Zipper | Boot Material | Hood Material | Zipper/Material Interface |
| MSA Blue Max Model B | 50 | 10 | 20 | - | - | - | 5 | - | 15 | - | - |
| Lakeland Tychem 9400 Coverall - 91450 | 50 | 10 | 15 | - | - | - | 5 | - | 15 | - | 5 |
| Kappler CPF3 Coverall 3T436 | 50 | 10 | 15 | - | - | - | 5 | - | 15 | - | 5 |
| MarMac Tyvek/Saranex 23-P Coverall | 50 | 10 | 15 | - | - | - | 5 | - | 15 | - | 5 |
| ILC Model 16-51 Coverall | 50 | 10 | 15 | - | - | - | - | 5 | - | 15 | 5 |
| Trelleborg Splash 700 1Piece Suit | 50 | - | 15 | 5 | 15 | 10 | - | - | - | - | 5 |

3.2.3 Correlation Between Liquid Challenge/Vapor Penetration Test Results and Skin Exposure.

The permeation test is designed to distinguish among these material swatches according to their permeation resistance to chemical agents. It's not intended to specifically replicate threat scenarios that may be encountered in actual use. In the author's opinion, 10 g/m² is a very severe challenge for a long period of time. As previously reported by Richard Belmonte, it is instructive to estimate the agent dosage ($C_{i,skin}$) that would result from such a standard agent challenge as a relative indication of possible physiological effects. This is done by converting the weighted average M_f s to equivalent agent dosages. This relationship was developed by Paul Fedele (written communication, Dr. P. Fedele, R&T Directorate, ERDEC, July 1997) and was reported by Richard Belmonte. For suit materials impermeable to airflow, the equation is:

$$\text{Agent Dosage (mg - min/m}^3) = \frac{M_f \text{ (ng/cm}^2)}{\text{Permeability of skin to agent vapor (cm/min)}}$$

where skin permeability is 2 cm/min for HD and 0.1 cm/min for GB. The agent dosage can then be compared to doses that are known to cause certain levels of toxicity. It is assumed that skin permeation of HD and GB are roughly equivalent over the entire body.

3.2.4 Test Criteria for Liquid Challenge/Vapor Penetration Testing.

When analyzing the test results it is useful to determine whether the data indicate that the Level B suit provides percutaneous protection over some period of time. HD vapor can produce

erythema (reddening of the skin) at dosages of approximately 100 mg-min/m³, and can produce vesication (skin burns and blisters) at 200 mg-min/m³. GB vapor can produce incapacitation at dosages of approximately 8000 mg-min/m³ and can cause lethality at dosages of 15000 mg-min/m³ where exposed persons are healthy, young, fit, and well-nourished males of approximately 70-kg mass. People who are smaller, less fit, etc., may exhibit adverse effects at lower doses ($C_{i,skin}$). The amount of agent per unit area (weighted average M_f) that would have to permeate the suit to produce a predetermined physiological effect was estimated by using each of the above dosages and the appropriate skin permeability (P_s). These values are used in the graphs of weighted average M_f versus time given in appendixes D through I and summarized in Table 2. The breakthrough dosages are considered to be 100 mg-min/m³ for HD (reddening of skin) and 8000 mg-min/m³ for GB (incapacitation – twitching, convulsions or loss of consciousness). A breakthrough time is the time when the weighted average M_f equals the breakthrough dosage criterion.

Table 2. Agent Breakthrough Criteria

| Agent | Breakthrough Dosage (mg-min/m ³) | Physiological Effect | Skin Permeability (P_s), (cm/min) | Breakthrough M_f , (ng/cm ²) |
|-------|--|----------------------|---------------------------------------|--|
| HD | 100 | Erythema | 2 | 200 |
| HD | 200 | Vesication | 2 | 400 |
| GB | 8000 | Incapacitation | 0.1 | 800 |
| GB | 15000 | Lethality | 0.1 | 1500 |

3.3 System Test (Aerosol Simulant)

3.3.1 Aerosol Simulant Test Procedures.

The testing is conducted to determine leakage of a challenge corn-oil aerosol (physical simulant of a biological agent aerosol) into a suit ensemble using people and ensembles of different sizes. Volunteers dressed in Level B suits with self-contained breathing apparatus enter a chamber with aerosol simulant. Instrumentation measures any aerosol leakage (penetration) into the suit through gaps between ensemble components. During the test, the people in the suits perform standardized movements. A brief description of the test and movements made by the people during the test are given in Appendix C. Eight different ensembles, listed in Appendix A, were tested.

From this test a protection factor is derived. In simplest terms, protection factor is a measure of the challenge outside the suit divided by the concentration inside the suit ensemble. For example, if the concentration of aerosol inside the suit ensemble is found to be 1/10th the value of the average concentration outside the suit ensemble, the PF is equal to 10.

3.3.2 Aerosol Simulant Analysis.

Samples of aerosol are taken continuously at the visor and upper arm within the suit and their concentrations are measured by laser photometry, recorded in a computer file and displayed continuously on a computer monitor. These sampling locations were selected as being the most likely locations for aerosol leakage to occur.

The protection factor (PF) data are presented based upon predetermined protection factor pass levels, ranging from 10 to 100,000; i.e. at each pass level the number of failing and passing suits is recorded. The higher the percentage of test occasions that passes at a given PF, the greater the probability that the suit will provide that level of protection in use. A complete technical report will be or has been prepared for each suit ensemble containing all system test (aerosol simulant) results.

A significant observation made during the aerosol simulant testing was that the MarMac Tyvek/Saranex suit tore easily while being worn by properly-sized volunteers (see note after Table G-3).

ACRONYMS and ABBREVIATIONS

| | |
|-----------------------|--|
| Ct | Vapor exposure, product of vapor concentration (mg/m^3) and time (minutes) |
| $C_{f_{\text{skin}}}$ | Vapor exposure to skin |
| cm^2 | Square centimeters |
| $^{\circ}\text{F}$ | Temperature in degrees Fahrenheit |
| delta p | Differential pressure |
| DoD | Department of Defense |
| ECBC | U.S. Army Edgewood Chemical Biological Center |
| ERDEC | U.S. Army Edgewood Research, Development and Engineering Center |
| g | Gram |
| GB | Sarin, Isopropylmethylphosphonofluoridate |
| HD | Sulfur Mustard; 2,2'-Dichlorodiethylsulfide |
| L | Liter |
| M_f | Cumulative mass permeation through the fabric |
| m^2 | Square meters |
| m^3 | Cubic meters |
| mg | Milligram |
| μL | Microliter |
| ng | Nanogram |
| NBC | Nuclear, Biological and Chemical |
| OSHA | Occupational Safety and Health Administration |
| PCT | Pre-concentrator tube |
| PF | Protection Factor |
| PPE | Personal Protective Equipment |
| P_s | Skin permeability |
| RH | Relative Humidity |
| SCBA | Self-Contained Breathing Apparatus |
| TOP | Test Operations Procedure |

Blank

Appendix A - Level B Suits Chosen for Testing

Table A-1. Level B Suits Tested

| Model | Manufacturer | Address |
|---|--|------------------|
| Kappler CPF3 Coverall 3T436 | Kappler Protective Apparel and Fabrics | Guntersville, AL |
| Lakeland Tychem 9400 Coverall – 94150 | Lakeland Industries, Inc. | Somerville, AL |
| MarMac Tyvek/Saranex 23-P Coverall | MarMac Manufacturing, Inc. | McBee, SC |
| ILC Dover Model 16-51 Coverall | ILC Dover, Inc. | Frederica, DE |
| MSA Blue Max Hazmat Splash Clothing Model B | Mine Safety Appliances Co. | Pittsburgh, PA |
| Trelleborg Splash 700 – 1 Piece Suit | Trelleborg Viking, Inc. | Ystad, Sweden |

Blank

Appendix B. - Modified Static Diffusion Test Procedure

MODIFIED STATIC DIFFUSION TEST

This test procedure was adapted from the “Semipermeable and Impermeable Materials Static Diffusion Penetration Testing (Liquid Agent Challenge/Vapor Penetration; $\Delta p = 0$, Single Flow Test) given in TOP 8-2-501 dated 03/03/97. The following procedure was used:

1. Upon receipt of a suit, all available information concerning the suit will be recorded; date of manufacture, lot number, serial number, materials of construction, etc.
2. From each suit, 3 ea 1 and 15/16-inch diameter material swatches will be taken for HD and a like number taken for GB. Depending upon the suit configuration, 3 seam swatches (same diameter) will be taken plus triplicate swatches of other flat components such as visor, gloves, suit/visor interface and zipper/material interface for HD and an equal number for GB. Each swatch will be placed in an airtight bag and given a unique serial number, which will be placed, on the bag. A list of serial numbers will be kept with the swatches. Alternatively, the swatches for each day's test will be cut from the suit and placed in the environmental chamber for conditioning. Sample identification will accompany each swatch.
3. The environmental chamber will be controlled at a temperature of 90 ± 2 °F and the maximum achievable relative humidity without occurrence of condensation (normally $50\% \pm 10\%$ RH). The temperature and RH readings will be checked weekly with a calibrated meter. The test cell air will be drawn from the chamber air. TOP 8-2-501 specifies that a system control and data acquisition system will be used but this system will not be used due to budget constraints. The temperature and RH will be recorded in a computer file. Flow rates will be manually recorded. TOP 8-2-501 specifies that differential pressure monitoring will be done but differential pressure gages will not be used due to budget constraints.
4. The TOP test cell will be used. When assembling, the cell lugs will be tightened by hand to finger tight. The flow rate beneath each swatch will be 1 L/min, which will be controlled by a linear mass flow controller. The flows will be checked with a calibrated test meter weekly. Each test cell will be checked for leaks after assembly by connecting it to the vacuum source and checking that the inlet flow is the same as the outlet flow on the mass flow controller. If the flows don't match; the test cell will be disassembled, adjustments made, the test cell reassembled and flows rechecked.
5. TOP 8-2-501 specifies that positive control and negative control swatches will be used but they will not be used due to budgetary and schedule limitations. The swatches will be preconditioned for at least 2 hours and will be monitored by MINICAMS for at least one cycle prior to agent application. Eighty-mil silicone will be used as an indicator of agent vapor permeation, 1 for each test (6 suit swatches and 1 silicone indicator swatch).
6. Agents GB and HD will be used. The contamination density will be 10 g/m^2 (8 ea 1 μL HD droplets or 10 ea 1 μL GB droplets). A robotic agent application system is not available. The agent will be applied using the click/touch method with a Hamilton repeating dispenser.
7. Seven swatches will be tested at once. MINICAMS with stream selection system will monitor vapor penetration with a 3-minute cycle. There will be 3 sampling intervals following the silicone during which chamber air will be sampled. Each swatch will be sampled once every 30 minutes. The MINICAMS will be standardized weekly with a range of agent standards; concentrations will normally range from 1 ng/ μL to 100 ng/ μL .

8. The test length will be 24 hours.
9. The test cells and O-rings will be aerated between uses. No other cleaning method will be used.
10. The data to be reported are cumulative permeation (ng/cm^2) at various elapsed times (minutes) for each swatch. The elapsed time for each swatch is the time from agent contamination. All recorded data will be placed in laboratory notebooks and one technical report per suit will be drafted at the conclusion of this effort.

Appendix C - Aerosol Simulant Test Procedure

In order to properly test suits with statistical significance, 8 suit ensembles of each model are provided to the Mask Fit Test Facility for examination. Each ensemble is new and inspected as received. The suit ensembles include relevant accessory equipment such respirators that are worn with the suits, gloves, boots, and any other equipment that is necessary for chemical agent use. The suit ensembles are run on at least 10 different subjects with at least 22 trials. The eight suits are reused to achieve the 22 or more trials. Sampling of suits is done at the neck and upper arm for each trial.

Exercise routine for all suits is:

Phase 1 (Pre-Operational):

- 1) standing still, normal breathing
- 2) bending forward and touching toes
- 3) jogging in place
- 4) raising arms above head and looking upward
- 5) bending knees and squatting
- 6) crawling on hands and knees
- 7) torso twists with hands folded on chest
- 8) standing still, normal breathing

Phase 2 (Operational):

- 1) climb step ladder
- 2) move 3 lb. boxes from table to floor
- 3) rest
- 4) roll walls and ceiling
- 5) bag clothes
- 6) rest
- 7) loosen bolts
- 8) move 3 lb boxes from floor to table

Note: The phase 1 (pre-operational) exercises are performed for 1 minute each for a total of eight minutes. The phase 2 (operational) exercises are performed for four minutes each for a total of 40 minutes.

Blank



Figure D-1: MSA Blue Max Model B- Front View

[picture not available]

Figure D-2: MSA Blue Max Model B - Side View

Table D-1. MSA Blue Max - Average HD Permeation

| MSA Blue Max Hazmat Splash Clothing Model B | | | | | | | | | | | |
|---|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|--------|---------------------|-----------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | |
| Time (min.) | Suit Matl | Time (min.) | Suit Seam | Time (min.) | Boot Seam | Time (min.) | Boot Matl | Time (min.) | Crotch | Average Time (min.) | Weighted Avg M _f |
| 5 | 2 | 14 | 1 | 14 | 1 | 5 | 1 | 7 | 0 | 9 | 1 |
| 35 | 35 | 44 | 4 | 44 | 7 | 35 | 10 | 37 | 0 | 39 | 20 |
| 65 | 68 | 74 | 7 | 74 | 13 | 65 | 23 | 67 | 0 | 69 | 40 |
| 95 | 103 | 104 | 12 | 104 | 15 | 95 | 31 | 97 | 0 | 99 | 59 |
| 125 | 140 | 134 | 20 | 134 | 15 | 125 | 39 | 127 | 0 | 129 | 81 |
| 155 | 178 | 164 | 28 | 164 | 16 | 155 | 50 | 157 | 0 | 159 | 103 |
| 185 | 219 | 194 | 36 | 194 | 21 | 185 | 63 | 187 | 0 | 189 | 127 |
| 215 | 260 | 224 | 46 | 224 | 30 | 215 | 77 | 217 | 0 | 219 | 152 |
| 245 | 302 | 254 | 55 | 254 | 39 | 245 | 93 | 247 | 1 | 249 | 178 |
| 275 | 344 | 284 | 65 | 284 | 48 | 275 | 109 | 277 | 3 | 279 | 204 |
| 305 | 389 | 314 | 76 | 314 | 58 | 305 | 127 | 307 | 5 | 309 | 232 |
| 335 | 433 | 344 | 84 | 344 | 69 | 335 | 146 | 337 | 8 | 339 | 259 |
| 365 | 479 | 374 | 87 | 374 | 80 | 365 | 166 | 367 | 12 | 369 | 287 |
| 395 | 527 | 404 | 93 | 404 | 93 | 395 | 187 | 397 | 16 | 399 | 316 |
| 425 | 577 | 434 | 104 | 434 | 106 | 425 | 209 | 427 | 20 | 429 | 348 |
| 455 | 627 | 464 | 116 | 464 | 118 | 455 | 232 | 457 | 24 | 459 | 380 |
| 485 | 677 | 494 | 128 | 494 | 131 | 485 | 254 | 487 | 28 | 489 | 412 |
| 515 | 726 | 524 | 140 | 524 | 145 | 515 | 277 | 517 | 32 | 519 | 443 |
| 545 | 774 | 554 | 152 | 554 | 158 | 545 | 300 | 547 | 36 | 549 | 474 |
| 575 | 822 | 584 | 164 | 584 | 172 | 575 | 323 | 577 | 39 | 579 | 505 |
| 605 | 868 | 614 | 175 | 614 | 184 | 605 | 346 | 607 | 42 | 609 | 534 |
| 635 | 914 | 644 | 186 | 644 | 197 | 635 | 368 | 637 | 46 | 639 | 564 |
| 665 | 957 | 674 | 196 | 674 | 210 | 665 | 390 | 667 | 49 | 669 | 592 |
| 695 | 999 | 704 | 203 | 704 | 222 | 695 | 411 | 697 | 51 | 699 | 618 |
| 725 | 1041 | 734 | 211 | 734 | 234 | 725 | 432 | 727 | 53 | 729 | 645 |
| 755 | 1082 | 764 | 221 | 764 | 246 | 755 | 453 | 757 | 55 | 759 | 671 |
| 785 | 1123 | 794 | 232 | 794 | 258 | 785 | 473 | 787 | 57 | 789 | 697 |
| 815 | 1164 | 824 | 242 | 824 | 269 | 815 | 493 | 817 | 59 | 819 | 724 |
| 845 | 1204 | 854 | 253 | 854 | 281 | 845 | 513 | 847 | 61 | 849 | 750 |
| 875 | 1244 | 884 | 264 | 884 | 292 | 875 | 532 | 877 | 63 | 879 | 776 |
| 905 | 1282 | 914 | 274 | 914 | 302 | 905 | 550 | 907 | 65 | 909 | 800 |
| 935 | 1321 | 944 | 285 | 944 | 313 | 935 | 567 | 937 | 67 | 939 | 825 |
| 965 | 1359 | 974 | 294 | 974 | 323 | 965 | 584 | 967 | 68 | 969 | 849 |
| 995 | 1396 | 1004 | 304 | 1004 | 332 | 995 | 601 | 997 | 70 | 999 | 873 |
| 1025 | 1433 | 1034 | 311 | 1034 | 342 | 1025 | 617 | 1027 | 72 | 1029 | 896 |
| 1055 | 1469 | 1064 | 318 | 1064 | 352 | 1055 | 633 | 1057 | 73 | 1059 | 918 |
| 1085 | 1503 | 1094 | 326 | 1094 | 361 | 1085 | 649 | 1087 | 74 | 1089 | 940 |
| 1115 | 1534 | 1124 | 334 | 1124 | 371 | 1115 | 665 | 1117 | 74 | 1119 | 960 |
| 1145 | 1564 | 1154 | 342 | 1154 | 380 | 1145 | 680 | 1147 | 74 | 1149 | 979 |
| 1175 | 1592 | 1184 | 350 | 1184 | 389 | 1175 | 695 | 1177 | 74 | 1179 | 997 |
| 1205 | 1615 | 1214 | 354 | 1214 | 398 | 1205 | 709 | 1207 | 74 | 1209 | 1012 |
| 1235 | 1635 | 1244 | 354 | 1244 | 406 | 1235 | 724 | 1237 | 74 | 1239 | 1025 |
| 1265 | 1653 | 1274 | 354 | 1274 | 413 | 1265 | 738 | 1267 | 74 | 1269 | 1036 |
| 1295 | 1672 | 1304 | 355 | 1304 | 418 | 1295 | 752 | 1297 | 74 | 1299 | 1048 |
| 1325 | 1695 | 1334 | 357 | 1334 | 420 | 1325 | 765 | 1327 | 74 | 1329 | 1062 |
| 1355 | 1719 | 1364 | 360 | 1364 | 420 | 1355 | 778 | 1357 | 74 | 1359 | 1077 |
| 1385 | 1743 | 1394 | 364 | 1394 | 422 | 1385 | 789 | 1387 | 74 | 1389 | 1091 |
| 1415 | 1767 | 1424 | 367 | 1424 | 424 | 1415 | 797 | 1417 | 74 | 1419 | 1105 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.2(Suit Seam M_f) + 0.05(Boot Seam M_f) + 0.15(Boot Matl M_f) + 0.1(Crotch M_f)

Table D-2. MSA Blue Max - Average GB Permeation

| MSA Blue Max Hazmat Splash Clothing Model B | | | | | | | | | | | |
|---|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|--------|---------------------|-----------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | |
| Time (min.) | Suit Matl | Time (min.) | Suit Seam | Time (min.) | Boot Seam | Time (min.) | Boot Matl | Time (min.) | Crotch | Average Time (min.) | Weighted Avg M _f |
| 5 | 0 | 14 | 0 | 13 | 0 | 4 | 0 | 7 | 0 | 9 | 0 |
| 35 | 5 | 44 | 125 | 43 | 639 | 34 | 5 | 37 | 8 | 39 | 61 |
| 65 | 36 | 74 | 415 | 73 | 1938 | 64 | 15 | 67 | 25 | 69 | 203 |
| 95 | 91 | 104 | 748 | 103 | 3262 | 94 | 28 | 97 | 45 | 99 | 367 |
| 125 | 145 | 134 | 1084 | 133 | 4584 | 124 | 46 | 127 | 64 | 129 | 532 |
| 155 | 191 | 164 | 1413 | 163 | 5901 | 154 | 66 | 157 | 80 | 159 | 691 |
| 185 | 231 | 194 | 1735 | 193 | 7209 | 184 | 85 | 187 | 96 | 189 | 845 |
| 215 | 265 | 224 | 2047 | 223 | 8506 | 214 | 103 | 217 | 110 | 219 | 994 |
| 245 | 294 | 254 | 2352 | 253 | 9799 | 244 | 120 | 247 | 124 | 249 | 1138 |
| 275 | 321 | 284 | 2657 | 283 | 11084 | 274 | 136 | 277 | 136 | 279 | 1280 |
| 305 | 346 | 314 | 2962 | 313 | 12361 | 304 | 150 | 307 | 147 | 309 | 1421 |
| 335 | 369 | 344 | 3263 | 343 | 13625 | 334 | 164 | 337 | 158 | 339 | 1559 |
| 365 | 390 | 374 | 3557 | 373 | 14877 | 364 | 176 | 367 | 167 | 369 | 1693 |
| 395 | 410 | 404 | 3843 | 403 | 16113 | 394 | 187 | 397 | 176 | 399 | 1825 |
| 425 | 427 | 434 | 4120 | 433 | 17311 | 424 | 198 | 427 | 184 | 429 | 1951 |
| 455 | 444 | 464 | 4387 | 463 | 18451 | 454 | 207 | 457 | 192 | 459 | 2072 |
| 485 | 459 | 494 | 4645 | 493 | 19520 | 484 | 216 | 487 | 199 | 489 | 2187 |
| 515 | 473 | 524 | 4893 | 523 | 20526 | 514 | 224 | 517 | 205 | 519 | 2296 |
| 545 | 486 | 554 | 5133 | 553 | 21474 | 544 | 232 | 547 | 211 | 549 | 2399 |
| 575 | 498 | 584 | 5362 | 583 | 22396 | 574 | 240 | 577 | 217 | 579 | 2499 |
| 605 | 509 | 614 | 5583 | 613 | 23319 | 604 | 247 | 607 | 223 | 609 | 2596 |
| 635 | 519 | 644 | 5794 | 643 | 24226 | 634 | 255 | 637 | 228 | 639 | 2691 |
| 665 | 529 | 674 | 5996 | 673 | 25112 | 664 | 262 | 667 | 232 | 669 | 2782 |
| 695 | 538 | 704 | 6190 | 703 | 25969 | 694 | 269 | 697 | 237 | 699 | 2870 |
| 725 | 547 | 734 | 6375 | 733 | 26796 | 724 | 275 | 727 | 242 | 729 | 2954 |
| 755 | 555 | 764 | 6552 | 763 | 27585 | 754 | 281 | 757 | 247 | 759 | 3034 |
| 785 | 562 | 794 | 6721 | 793 | 28329 | 784 | 287 | 787 | 252 | 789 | 3110 |
| 815 | 569 | 824 | 6883 | 823 | 29033 | 814 | 292 | 817 | 257 | 819 | 3182 |
| 845 | 576 | 854 | 7041 | 853 | 29700 | 844 | 295 | 847 | 262 | 849 | 3252 |
| 875 | 582 | 884 | 7190 | 883 | 30328 | 874 | 298 | 877 | 266 | 879 | 3317 |
| 905 | 588 | 914 | 7334 | 913 | 30915 | 904 | 300 | 907 | 270 | 909 | 3379 |
| 935 | 594 | 944 | 7473 | 943 | 31464 | 934 | 301 | 937 | 274 | 939 | 3437 |
| 965 | 600 | 974 | 7607 | 973 | 31983 | 964 | 302 | 967 | 277 | 969 | 3494 |
| 995 | 605 | 1004 | 7734 | 1003 | 32470 | 994 | 302 | 997 | 280 | 999 | 3546 |
| 1025 | 609 | 1034 | 7857 | 1033 | 32934 | 1024 | 302 | 1027 | 283 | 1029 | 3596 |
| 1055 | 612 | 1064 | 7975 | 1063 | 33379 | 1054 | 302 | 1057 | 285 | 1059 | 3644 |
| 1085 | 613 | 1094 | 8087 | 1093 | 33794 | 1084 | 302 | 1087 | 287 | 1089 | 3688 |
| 1115 | 614 | 1124 | 8192 | 1123 | 34183 | 1114 | 302 | 1117 | 289 | 1119 | 3729 |
| 1145 | 614 | 1154 | 8286 | 1153 | 34539 | 1144 | 302 | 1147 | 291 | 1149 | 3766 |
| 1175 | 614 | 1184 | 8373 | 1183 | 34865 | 1174 | 302 | 1177 | 293 | 1179 | 3799 |
| 1205 | 614 | 1214 | 8456 | 1213 | 35172 | 1204 | 302 | 1207 | 295 | 1209 | 3832 |
| 1235 | 614 | 1244 | 8537 | 1243 | 35464 | 1234 | 302 | 1237 | 297 | 1239 | 3863 |
| 1265 | 614 | 1274 | 8614 | 1273 | 35747 | 1264 | 302 | 1267 | 298 | 1269 | 3892 |
| 1295 | 614 | 1304 | 8688 | 1303 | 36026 | 1294 | 302 | 1297 | 300 | 1299 | 3921 |
| 1325 | 614 | 1334 | 8758 | 1333 | 36299 | 1324 | 302 | 1327 | 301 | 1329 | 3949 |
| 1355 | 614 | 1364 | 8827 | 1363 | 36567 | 1354 | 302 | 1357 | 303 | 1359 | 3976 |
| 1385 | 614 | 1394 | 8894 | 1393 | 36828 | 1384 | 302 | 1387 | 304 | 1389 | 4003 |
| 1415 | 614 | 1424 | 8957 | 1423 | 37085 | 1414 | 302 | 1417 | 305 | 1419 | 4028 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.2(Suit Seam M_f) + 0.05(Boot Seam M_f) + 0.15(Boot Matl M_f) + 0.1(Crotch M_f)

MSA Blue Max Hazmat Splash Clothing Model B

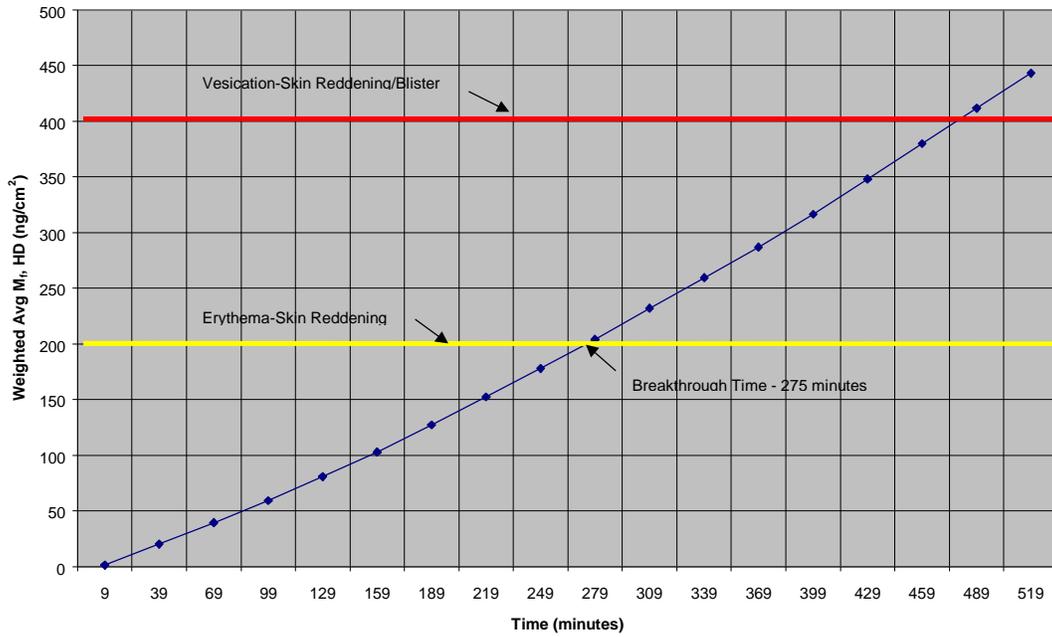


Figure D-3: MSA Blue Max - Weighted Average HD Permeation

MSA Blue Max Hazmat Splash Clothing Model B

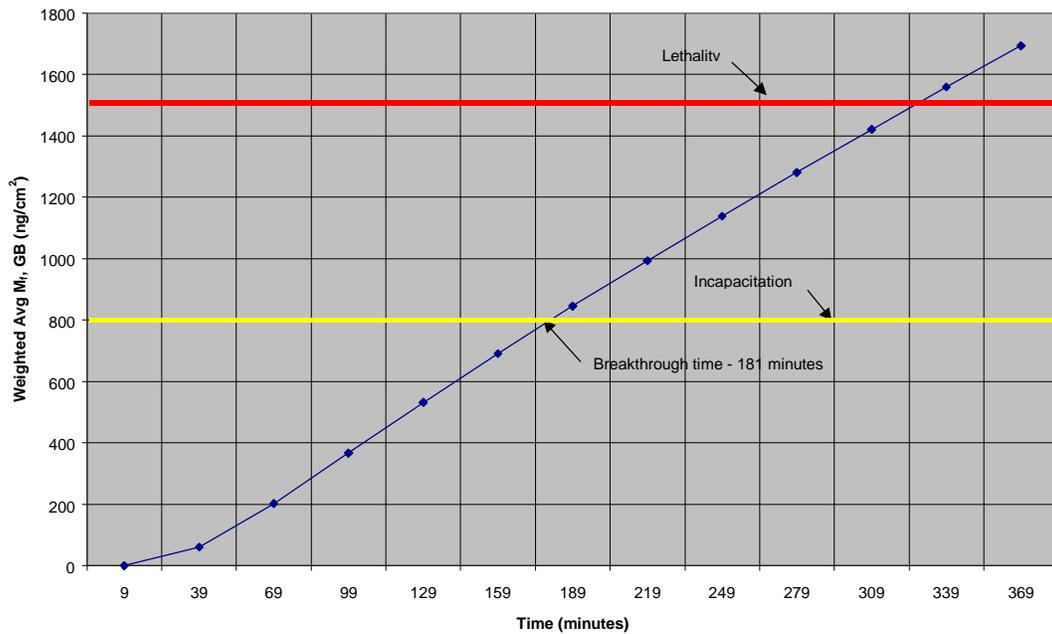


Figure D-4: MSA Blue Max - Weighted Average GB Permeation

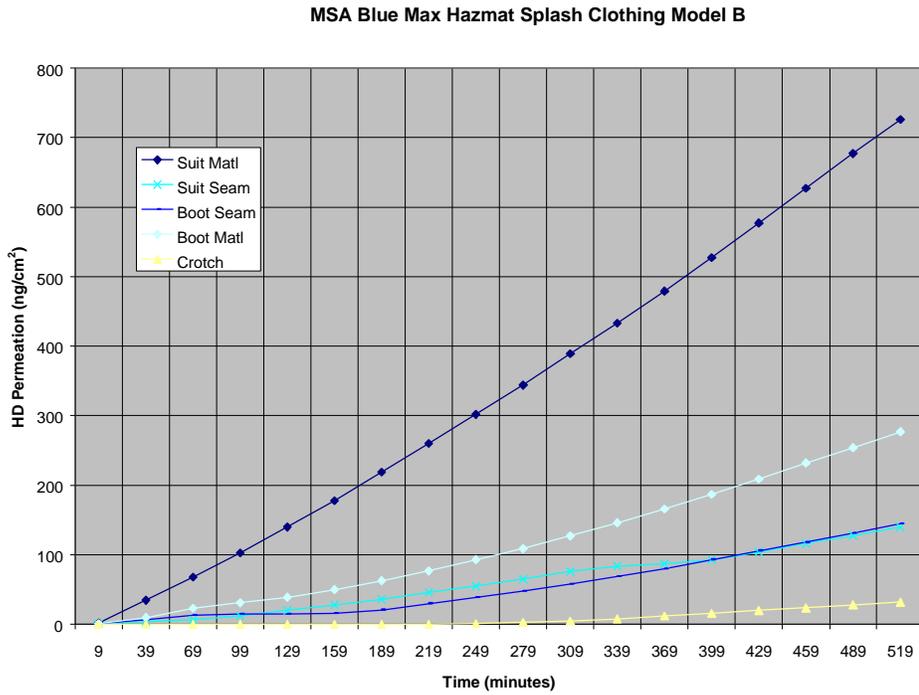


Figure D-5: MSA Blue Max: HD Permeation by Sampling Area

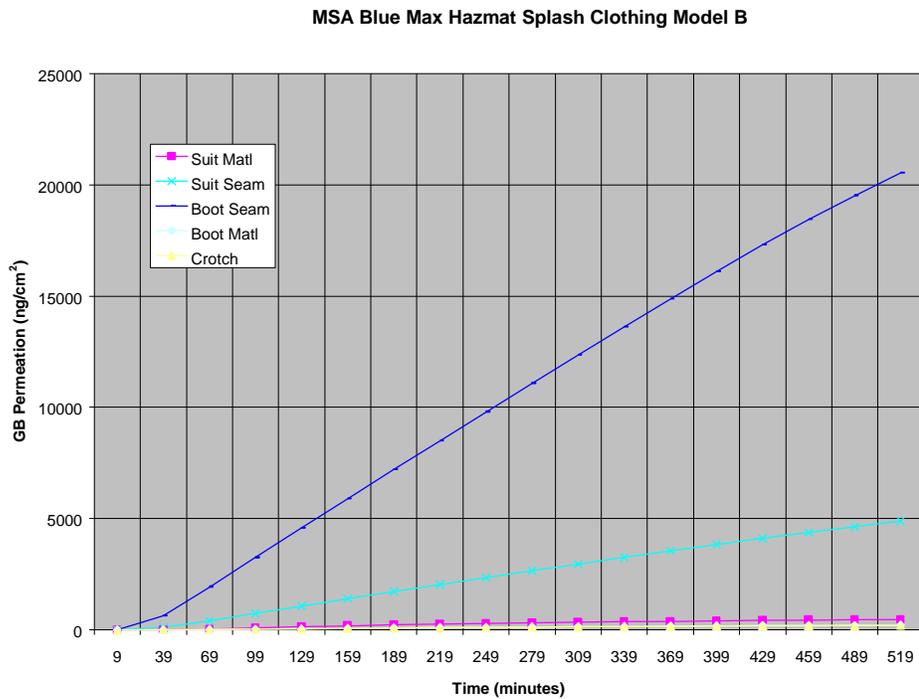


Figure D-6: MSA Blue Max: GB Permeation by Sampling Area

Table D-3.MSA Blue Max Model B - System Test (Aerosol Simulant) Results

| PF Range | Visor Region and Upper Arm, Combined | | | | | |
|---------------|--------------------------------------|--------------------------|-------------------------------|---------------------------|--------------------------|-------------------------------|
| | Pre-Operational Exercises | | | Operational Exercises | | |
| | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent |
| 0-9 | 32 | 100 | 0 | 32 | 100 | 0 |
| 10-49 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50-99 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100-499 | 0 | 0 | 0 | 0 | 0 | 0 |
| 500-999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1000-1666 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1667-4999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5000-6666 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6667-9999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10000-19999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000-49999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50000-99999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100000+ | 0 | 0 | 0 | 0 | 0 | 0 |
| No. of Trials | 32 | | | 32 | | |

Table D-4. MSA Blue Max Model B - Overall Test Results

| Breakthrough Time (minutes) | | Aerosol PF Pass Rate at PF Equal to: | | | Exercise Phase |
|-----------------------------|----------|--------------------------------------|-----|-----|--------------------------------|
| Incapacitation | Erythema | 10 | 50 | 100 | |
| GB | HD | 0.0 | 0.0 | 0.0 | Pre-Operational Operational |
| 181 | 275 | 0.0 | 0.0 | 0.0 | |



**Figure E-1: Lakeland Tychem 9400 Coverall - 94150
Front View**



**Figure E-2: Lakeland Tychem 9400 Coverall - 94150
Side View**

Table E-1. Lakeland TYCHEM 9400 Coverall – 94150 - Average HD Permeation

| Lakeland Tychem 9400 Coverall-94150 | | | | | | | | | | | | | |
|---|-----------|--------------|-----------|--------------|-------------|--------------|-----------|--------------|-----------|--------------|--------|----------------------|------------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time, (min.) | Suit Matl | Time, (min.) | Suit Seam | Time, (min.) | Zipper Matl | Time, (min.) | Boot Seam | Time, (min.) | Boot Matl | Time, (min.) | Crotch | Average Time, (min.) | Weighted Avg, M _f |
| 5 | 1 | 14 | 2 | 6 | 0 | 15 | 0 | 5 | 0 | 14 | 1 | 10 | 1 |
| 36 | 5 | 45 | 5 | 36 | 0 | 45 | 2 | 35 | 3 | 44 | 5 | 40 | 4 |
| 66 | 5 | 75 | 5 | 66 | 0 | 75 | 5 | 65 | 5 | 74 | 33 | 70 | 8 |
| 96 | 5 | 105 | 5 | 97 | 0 | 106 | 5 | 96 | 7 | 105 | 142 | 101 | 19 |
| 127 | 5 | 136 | 5 | 127 | 1 | 136 | 5 | 126 | 10 | 135 | 339 | 131 | 39 |
| 157 | 5 | 166 | 5 | 157 | 4 | 166 | 5 | 156 | 14 | 165 | 571 | 161 | 63 |
| 187 | 8 | 197 | 6 | 188 | 9 | 197 | 6 | 187 | 21 | 196 | 810 | 192 | 90 |
| 218 | 12 | 227 | 8 | 218 | 15 | 227 | 7 | 217 | 29 | 226 | 1059 | 222 | 119 |
| 248 | 18 | 257 | 11 | 248 | 21 | 257 | 10 | 247 | 38 | 256 | 1318 | 252 | 150 |
| 278 | 24 | 288 | 13 | 279 | 28 | 288 | 14 | 278 | 47 | 287 | 1578 | 283 | 181 |
| 309 | 31 | 318 | 17 | 309 | 35 | 318 | 19 | 308 | 57 | 317 | 1839 | 313 | 213 |
| 339 | 39 | 348 | 21 | 339 | 42 | 348 | 24 | 338 | 68 | 347 | 2102 | 343 | 246 |
| 369 | 46 | 379 | 26 | 370 | 50 | 379 | 29 | 369 | 79 | 378 | 2368 | 374 | 280 |
| 400 | 53 | 409 | 31 | 400 | 58 | 409 | 34 | 399 | 90 | 408 | 2636 | 404 | 313 |
| 430 | 60 | 439 | 37 | 430 | 66 | 439 | 40 | 429 | 101 | 438 | 2907 | 434 | 347 |
| 460 | 67 | 470 | 42 | 461 | 74 | 470 | 45 | 460 | 112 | 469 | 3182 | 465 | 381 |
| 491 | 74 | 500 | 47 | 491 | 82 | 500 | 50 | 490 | 123 | 499 | 3459 | 495 | 415 |
| 521 | 81 | 530 | 52 | 521 | 89 | 530 | 55 | 520 | 133 | 529 | 3738 | 525 | 449 |
| 551 | 87 | 561 | 58 | 552 | 96 | 561 | 58 | 551 | 143 | 560 | 4020 | 556 | 483 |
| 582 | 94 | 591 | 63 | 582 | 103 | 591 | 62 | 581 | 153 | 590 | 4304 | 586 | 518 |
| 612 | 101 | 621 | 68 | 612 | 110 | 621 | 67 | 611 | 163 | 620 | 4590 | 616 | 553 |
| 642 | 107 | 652 | 73 | 643 | 117 | 652 | 69 | 642 | 172 | 651 | 4879 | 647 | 587 |
| 673 | 114 | 682 | 77 | 673 | 124 | 682 | 71 | 672 | 181 | 681 | 5171 | 677 | 623 |
| 703 | 120 | 712 | 81 | 703 | 130 | 712 | 72 | 702 | 190 | 711 | 5463 | 707 | 657 |
| 733 | 125 | 743 | 84 | 734 | 137 | 743 | 73 | 733 | 199 | 742 | 5755 | 738 | 691 |
| 764 | 132 | 773 | 87 | 764 | 143 | 773 | 73 | 763 | 207 | 772 | 6047 | 768 | 726 |
| 794 | 138 | 803 | 91 | 794 | 149 | 803 | 73 | 793 | 216 | 802 | 6338 | 798 | 760 |
| 824 | 143 | 834 | 93 | 825 | 155 | 834 | 74 | 824 | 224 | 833 | 6631 | 829 | 794 |
| 855 | 149 | 864 | 95 | 855 | 161 | 864 | 75 | 854 | 232 | 863 | 6923 | 859 | 828 |
| 885 | 154 | 894 | 98 | 885 | 167 | 894 | 75 | 884 | 240 | 893 | 7213 | 889 | 861 |
| 915 | 160 | 925 | 101 | 916 | 173 | 925 | 75 | 915 | 248 | 924 | 7504 | 920 | 895 |
| 946 | 165 | 955 | 102 | 946 | 179 | 955 | 75 | 945 | 256 | 954 | 7794 | 950 | 928 |
| 976 | 170 | 985 | 104 | 976 | 184 | 985 | 75 | 975 | 264 | 984 | 8084 | 980 | 962 |
| 1006 | 175 | 1016 | 105 | 1007 | 190 | 1016 | 75 | 1006 | 272 | 1015 | 8375 | 1011 | 995 |
| 1037 | 180 | 1046 | 107 | 1037 | 195 | 1046 | 75 | 1036 | 280 | 1045 | 8666 | 1041 | 1028 |
| 1067 | 184 | 1076 | 108 | 1067 | 201 | 1076 | 75 | 1066 | 288 | 1075 | 8956 | 1071 | 1061 |
| 1097 | 188 | 1107 | 110 | 1098 | 205 | 1107 | 75 | 1097 | 296 | 1106 | 9246 | 1102 | 1094 |
| 1128 | 191 | 1137 | 111 | 1128 | 211 | 1137 | 75 | 1127 | 304 | 1136 | 9533 | 1132 | 1125 |
| 1158 | 194 | 1167 | 112 | 1158 | 216 | 1167 | 75 | 1157 | 311 | 1166 | 9820 | 1162 | 1157 |
| 1188 | 197 | 1198 | 112 | 1189 | 221 | 1198 | 75 | 1188 | 319 | 1197 | 10106 | 1193 | 1189 |
| 1219 | 199 | 1228 | 112 | 1219 | 226 | 1228 | 75 | 1218 | 326 | 1227 | 10394 | 1223 | 1220 |
| 1249 | 200 | 1258 | 112 | 1249 | 231 | 1258 | 75 | 1248 | 333 | 1257 | 10679 | 1253 | 1250 |
| 1279 | 202 | 1289 | 112 | 1280 | 236 | 1289 | 76 | 1279 | 341 | 1288 | 10961 | 1284 | 1281 |
| 1310 | 203 | 1319 | 112 | 1310 | 239 | 1319 | 77 | 1309 | 347 | 1318 | 11238 | 1314 | 1310 |
| 1340 | 205 | 1349 | 112 | 1340 | 241 | 1349 | 77 | 1339 | 353 | 1348 | 11512 | 1344 | 1339 |
| 1370 | 206 | 1380 | 112 | 1371 | 242 | 1380 | 77 | 1370 | 360 | 1379 | 11788 | 1375 | 1369 |
| 1401 | 207 | 1410 | 112 | 1401 | 244 | 1410 | 77 | 1400 | 366 | 1409 | 12066 | 1405 | 1398 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: $Wtd\ Avg\ M_f = 0.5(Suit\ Matl\ M_f) + 0.15(Suit\ Seam\ M_f) + 0.05(Boot\ Seam\ M_f) + 0.15(Boot\ Matl\ M_f) + 0.1(Crotch\ M_f) + 0.05(Zipper\ Matl\ Interface\ M_f)$

Table E-2. Lakeland TYCHEM 9400 Coverall – 94150 - Average GB Permeation

| Lakeland Tychem 9400 Coverall-94150 | | | | | | | | | | | | | |
|---|-----------|-------------|-----------|-------------|-------------|-------------|-----------|-------------|-----------|-------------|--------|---------------------|-----------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Matl | Time (min.) | Suit Seam | Time (min.) | Zipper Matl | Time (min.) | Boot Seam | Time (min.) | Boot Matl | Time (min.) | Crotch | Average Time (min.) | Weighted Avg M _f |
| 14 | 0 | 5 | 0 | 3 | 1 | 13 | 6 | 5 | 0 | 14 | 0 | 9 | 0 |
| 45 | 35 | 36 | 31 | 34 | 15 | 43 | 40 | 35 | 12 | 44 | 214 | 40 | 48 |
| 75 | 114 | 66 | 111 | 64 | 58 | 73 | 85 | 65 | 80 | 74 | 611 | 70 | 154 |
| 106 | 198 | 97 | 203 | 94 | 150 | 103 | 138 | 95 | 167 | 105 | 968 | 100 | 266 |
| 136 | 268 | 127 | 278 | 125 | 283 | 134 | 193 | 126 | 222 | 135 | 1316 | 131 | 364 |
| 166 | 330 | 157 | 342 | 155 | 450 | 164 | 247 | 156 | 262 | 165 | 1658 | 161 | 456 |
| 197 | 387 | 188 | 397 | 185 | 640 | 194 | 300 | 186 | 295 | 195 | 1987 | 191 | 543 |
| 227 | 436 | 218 | 443 | 215 | 850 | 224 | 353 | 216 | 324 | 225 | 2307 | 221 | 624 |
| 257 | 479 | 248 | 482 | 246 | 1084 | 255 | 408 | 247 | 349 | 256 | 2619 | 252 | 701 |
| 288 | 518 | 279 | 515 | 276 | 1337 | 285 | 466 | 277 | 371 | 286 | 2933 | 282 | 775 |
| 318 | 552 | 309 | 544 | 306 | 1594 | 315 | 527 | 307 | 390 | 316 | 3248 | 312 | 847 |
| 348 | 582 | 339 | 571 | 336 | 1849 | 345 | 587 | 337 | 407 | 346 | 3560 | 342 | 916 |
| 379 | 610 | 370 | 594 | 366 | 2104 | 376 | 645 | 367 | 423 | 376 | 3867 | 372 | 982 |
| 409 | 634 | 400 | 615 | 397 | 2359 | 406 | 698 | 398 | 437 | 407 | 4168 | 403 | 1044 |
| 439 | 657 | 430 | 634 | 427 | 2612 | 436 | 748 | 428 | 452 | 437 | 4436 | 433 | 1103 |
| 470 | 678 | 461 | 652 | 457 | 2863 | 466 | 796 | 458 | 466 | 467 | 4670 | 463 | 1157 |
| 500 | 698 | 491 | 668 | 488 | 3112 | 497 | 839 | 488 | 479 | 497 | 4897 | 494 | 1208 |
| 530 | 716 | 521 | 682 | 518 | 3359 | 527 | 877 | 519 | 492 | 528 | 5115 | 524 | 1257 |
| 561 | 732 | 552 | 696 | 548 | 3606 | 557 | 912 | 549 | 504 | 558 | 5328 | 554 | 1305 |
| 591 | 748 | 582 | 708 | 578 | 3852 | 587 | 946 | 579 | 516 | 588 | 5539 | 584 | 1351 |
| 621 | 762 | 612 | 720 | 609 | 4097 | 618 | 979 | 609 | 527 | 618 | 5746 | 615 | 1396 |
| 652 | 774 | 643 | 731 | 639 | 4340 | 648 | 1012 | 639 | 538 | 648 | 5949 | 645 | 1440 |
| 682 | 787 | 673 | 741 | 669 | 4579 | 678 | 1045 | 670 | 549 | 679 | 6148 | 675 | 1483 |
| 712 | 798 | 703 | 750 | 699 | 4811 | 708 | 1076 | 700 | 559 | 709 | 6343 | 705 | 1524 |
| 743 | 809 | 734 | 759 | 730 | 5040 | 739 | 1105 | 730 | 569 | 739 | 6534 | 736 | 1564 |
| 773 | 819 | 764 | 767 | 760 | 5265 | 769 | 1133 | 760 | 579 | 769 | 6721 | 766 | 1603 |
| 803 | 828 | 794 | 775 | 790 | 5487 | 799 | 1159 | 790 | 588 | 800 | 6904 | 796 | 1641 |
| 834 | 837 | 825 | 782 | 820 | 5705 | 830 | 1185 | 821 | 597 | 830 | 7081 | 827 | 1678 |
| 864 | 845 | 855 | 789 | 851 | 5921 | 860 | 1209 | 851 | 605 | 860 | 7250 | 857 | 1713 |
| 894 | 853 | 885 | 796 | 881 | 6135 | 890 | 1232 | 881 | 613 | 890 | 7413 | 887 | 1748 |
| 925 | 862 | 916 | 802 | 911 | 6343 | 921 | 1255 | 911 | 622 | 920 | 7568 | 917 | 1781 |
| 955 | 870 | 946 | 808 | 942 | 6545 | 951 | 1276 | 942 | 629 | 951 | 7718 | 948 | 1813 |
| 985 | 877 | 976 | 813 | 972 | 6744 | 981 | 1295 | 972 | 637 | 981 | 7862 | 978 | 1844 |
| 1016 | 884 | 1007 | 817 | 1002 | 6940 | 1012 | 1315 | 1002 | 644 | 1011 | 8002 | 1008 | 1874 |
| 1046 | 890 | 1037 | 821 | 1033 | 7131 | 1042 | 1333 | 1032 | 651 | 1041 | 8136 | 1039 | 1903 |
| 1076 | 896 | 1067 | 826 | 1063 | 7315 | 1072 | 1350 | 1063 | 658 | 1072 | 8252 | 1069 | 1929 |
| 1107 | 902 | 1098 | 829 | 1093 | 7495 | 1102 | 1367 | 1093 | 666 | 1102 | 8351 | 1099 | 1953 |
| 1137 | 907 | 1128 | 833 | 1124 | 7670 | 1133 | 1382 | 1123 | 674 | 1132 | 8445 | 1130 | 1977 |
| 1167 | 912 | 1158 | 836 | 1154 | 7838 | 1163 | 1397 | 1153 | 681 | 1162 | 8539 | 1160 | 1999 |
| 1198 | 917 | 1189 | 840 | 1184 | 8001 | 1193 | 1412 | 1184 | 688 | 1193 | 8631 | 1190 | 2021 |
| 1228 | 922 | 1219 | 843 | 1215 | 8157 | 1224 | 1425 | 1214 | 696 | 1223 | 8723 | 1221 | 2043 |
| 1258 | 927 | 1249 | 846 | 1245 | 8310 | 1254 | 1438 | 1244 | 702 | 1253 | 8813 | 1251 | 2064 |
| 1289 | 931 | 1280 | 849 | 1275 | 8456 | 1284 | 1451 | 1274 | 709 | 1283 | 8902 | 1281 | 2085 |
| 1319 | 933 | 1310 | 852 | 1306 | 8596 | 1315 | 1463 | 1305 | 715 | 1314 | 8990 | 1312 | 2104 |
| 1349 | 936 | 1340 | 854 | 1336 | 8730 | 1345 | 1474 | 1335 | 721 | 1344 | 9076 | 1342 | 2122 |
| 1380 | 938 | 1371 | 856 | 1366 | 8862 | 1375 | 1485 | 1365 | 727 | 1374 | 9162 | 1372 | 2140 |
| 1410 | 940 | 1401 | 857 | 1397 | 8990 | 1406 | 1496 | 1395 | 733 | 1404 | 9245 | 1402 | 2157 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.15(Suit Seam M_f) + 0.05(Boot Seam M_f) + 0.15(Boot Matl M_f) + 0.1(Crotch M_f) + 0.05(Zipper Matl Interface M_f)

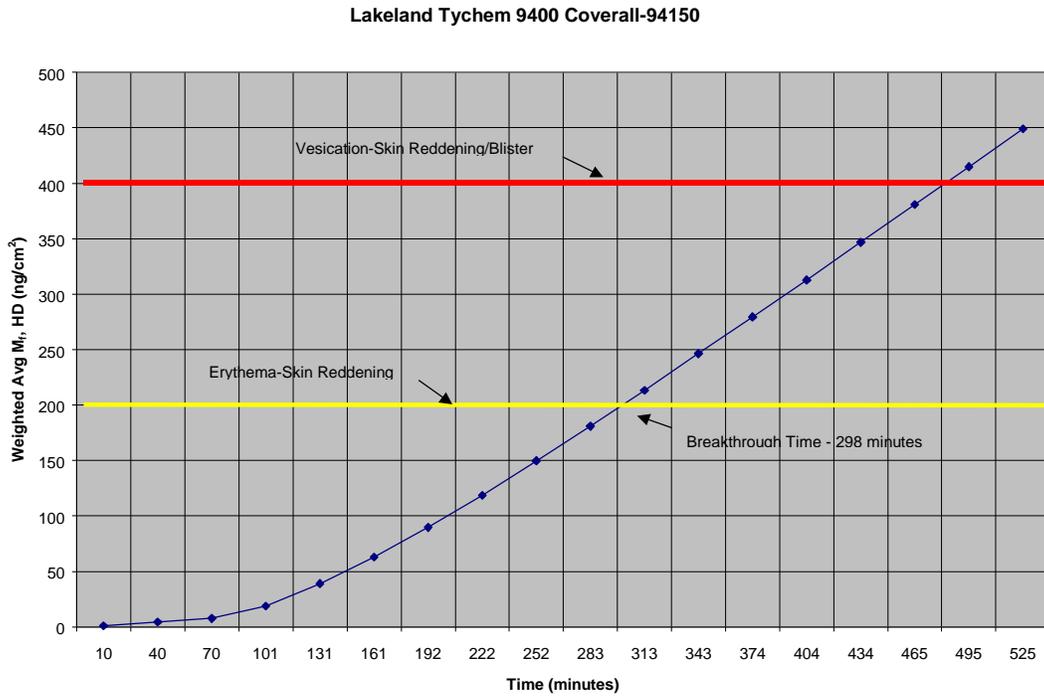


Figure E-3: Lakeland TYCHEM 9400 Coverall - 94150 - Weighted Average HD Permeation

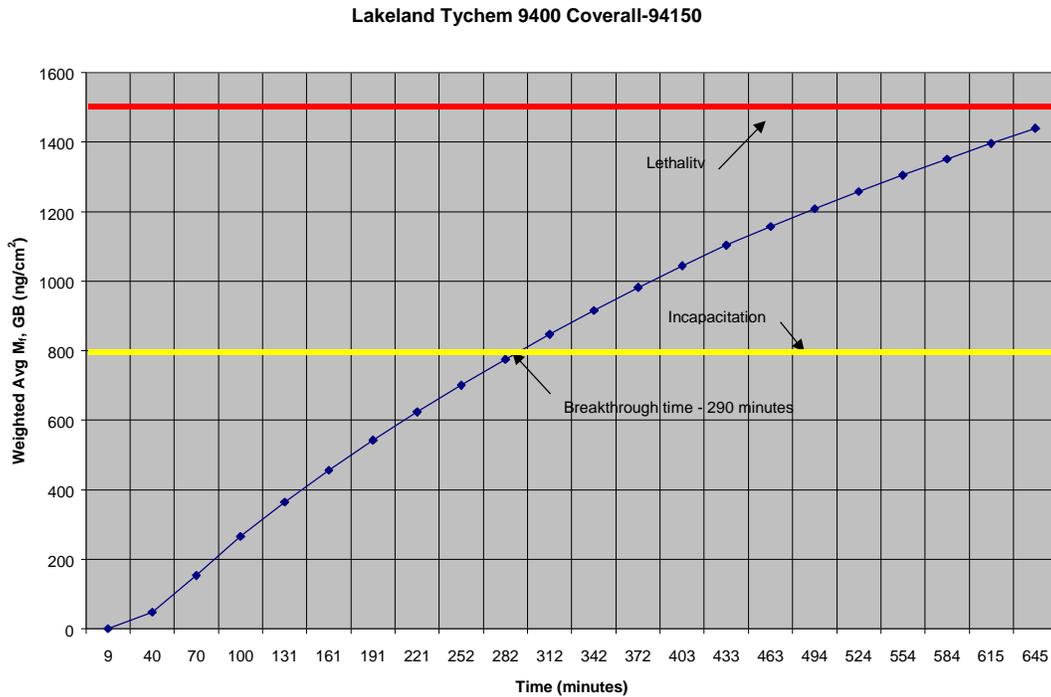


Figure E-4: Lakeland TYCHEM 9400 Coverall - 94150 - Weighted Average GB Permeation

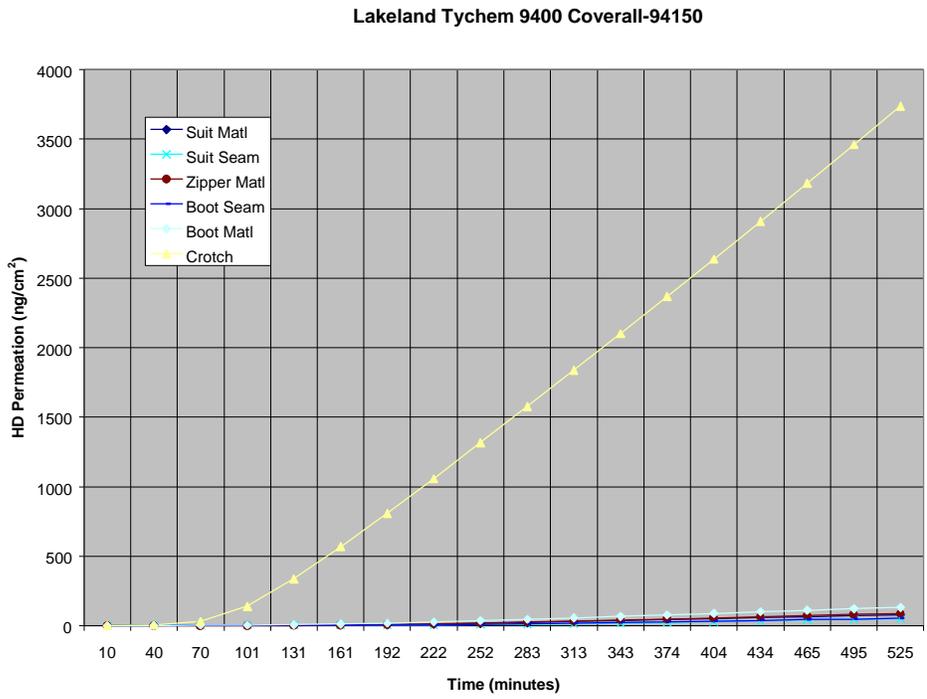


Figure E-5: Lakeland TYCHEM 9400 Coverall – 94150 - HD Permeation by Sampling Area

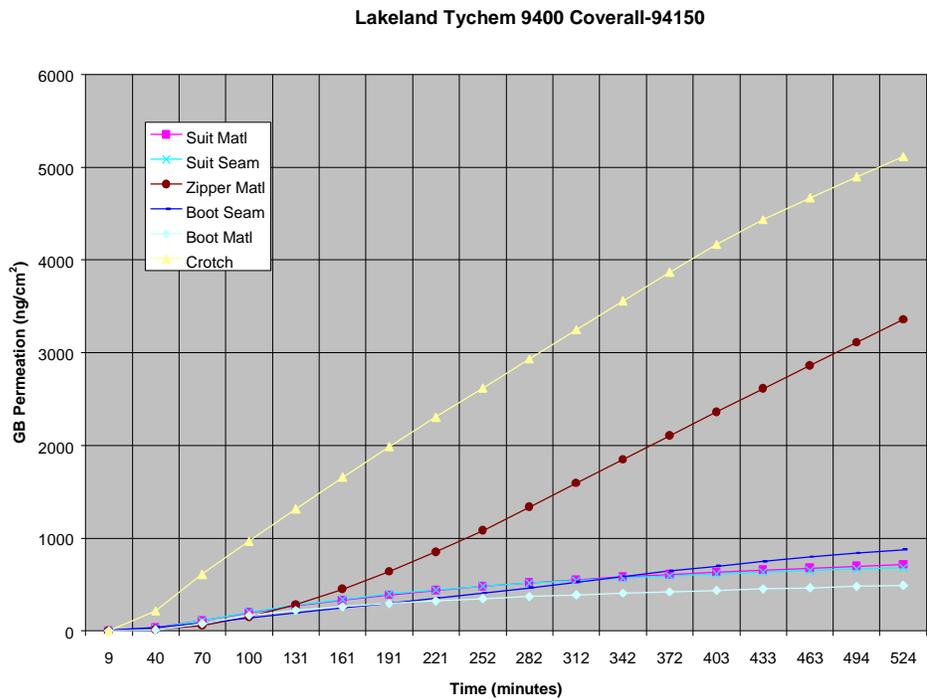


Figure E-6: Lakeland TYCHEM 9400 Coverall – 94150 - GB Permeation by Sampling Area

Table E-3. Lakeland TYCHEM 9400 Coverall - 94150 - System Test (Aerosol Simulant) Results

| PF Range | Visor Region and Upper Arm, Combined | | | | | |
|---------------|--------------------------------------|--------------------------|-------------------------------|---------------------------|--------------------------|-------------------------------|
| | Pre-Operational Exercises | | | Operational Exercises | | |
| | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent |
| 0-9 | 22 | 100 | 0 | 22 | 100 | 0 |
| 10-49 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50-99 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100-499 | 0 | 0 | 0 | 0 | 0 | 0 |
| 500-999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1000-1666 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1667-4999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5000-6666 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6667-9999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10000-19999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000-49999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50000-99999 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100000+ | 0 | 0 | 0 | 0 | 0 | 0 |
| No. of Trials | 22 | | | 22 | | |

Table E-4. Lakeland TYCHEM 9400 Coverall - 94150 - Overall Test Results

| Breakthrough Time (minutes) | | Aerosol PF Pass Rate at PF Equal to: | | | Exercise Phase |
|-----------------------------|----------|--------------------------------------|-----|-----|-----------------|
| Incapacitation | Erythema | 10 | 50 | 100 | |
| GB | HD | | | | |
| 290 | 298 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | 0.0 | 0.0 | 0.0 | Operational |



Figure F-1: Kappler CPF3 Coverall 3T436 - Front View



Figure F-2: Kappler CPF3 Coverall 3T436 - Side View

Table F-1. Kappler CPF3 - Average HD Permeation

| Kappler CPF3 Coverall 3T436 | | | | | | | | | | | | | |
|---|---------------|-------------|-----------|-------------|-----------------|-------------|-----------|-------------|-----------|-------------|--------|---------------------|------------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Material | Time (min.) | Suit Seam | Time (min.) | Zipper Material | Time (min.) | Boot Seam | Time (min.) | Boot Matl | Time (min.) | Crotch | Average Time (min.) | Weighted Avg. M _f |
| 6 | 1 | 15 | 3 | 13 | 2 | 13 | 0 | 4 | 1 | 4 | 0 | 9 | 1 |
| 36 | 43 | 45 | 15 | 43 | 10 | 43 | 0 | 34 | 10 | 34 | 0 | 39 | 26 |
| 66 | 109 | 75 | 24 | 73 | 16 | 73 | 0 | 64 | 18 | 64 | 0 | 69 | 62 |
| 96 | 407 | 105 | 35 | 103 | 22 | 103 | 0 | 94 | 26 | 94 | 2 | 99 | 214 |
| 126 | 1131 | 135 | 48 | 133 | 25 | 134 | 3 | 124 | 38 | 125 | 9 | 130 | 581 |
| 156 | 2049 | 165 | 65 | 163 | 31 | 164 | 14 | 154 | 54 | 155 | 30 | 160 | 1048 |
| 186 | 2970 | 195 | 84 | 193 | 43 | 194 | 37 | 184 | 73 | 185 | 72 | 190 | 1520 |
| 216 | 3880 | 225 | 107 | 223 | 56 | 224 | 75 | 214 | 97 | 215 | 133 | 220 | 1990 |
| 246 | 4785 | 255 | 134 | 253 | 70 | 254 | 128 | 244 | 123 | 245 | 208 | 250 | 2462 |
| 276 | 5695 | 285 | 166 | 283 | 86 | 284 | 190 | 274 | 151 | 275 | 292 | 280 | 2938 |
| 306 | 6610 | 315 | 202 | 313 | 103 | 315 | 259 | 304 | 180 | 306 | 382 | 310 | 3419 |
| 336 | 7534 | 345 | 243 | 343 | 121 | 345 | 334 | 334 | 212 | 336 | 475 | 340 | 3906 |
| 366 | 8459 | 375 | 290 | 373 | 141 | 375 | 413 | 364 | 244 | 366 | 572 | 370 | 4395 |
| 396 | 9384 | 405 | 341 | 403 | 161 | 405 | 493 | 394 | 278 | 396 | 669 | 400 | 4884 |
| 426 | 10307 | 435 | 395 | 433 | 181 | 435 | 575 | 424 | 313 | 426 | 768 | 430 | 5374 |
| 456 | 11224 | 465 | 453 | 463 | 203 | 465 | 658 | 454 | 349 | 456 | 868 | 460 | 5862 |
| 486 | 12134 | 495 | 513 | 493 | 225 | 496 | 744 | 484 | 385 | 487 | 968 | 490 | 6347 |
| 516 | 13044 | 525 | 575 | 523 | 247 | 526 | 830 | 514 | 420 | 517 | 1068 | 520 | 6832 |
| 546 | 13961 | 555 | 638 | 553 | 270 | 556 | 917 | 544 | 457 | 547 | 1168 | 550 | 7321 |
| 576 | 14885 | 585 | 702 | 583 | 294 | 586 | 1002 | 574 | 493 | 577 | 1266 | 580 | 7813 |
| 606 | 15811 | 615 | 768 | 613 | 319 | 616 | 1087 | 604 | 531 | 607 | 1363 | 610 | 8307 |
| 636 | 16740 | 645 | 834 | 643 | 346 | 646 | 1171 | 634 | 572 | 637 | 1458 | 640 | 8803 |
| 666 | 17677 | 675 | 899 | 673 | 378 | 677 | 1254 | 664 | 615 | 668 | 1550 | 671 | 9302 |
| 696 | 18623 | 705 | 966 | 703 | 413 | 707 | 1334 | 694 | 662 | 698 | 1640 | 701 | 9807 |
| 726 | 19564 | 735 | 1033 | 733 | 453 | 737 | 1413 | 724 | 710 | 728 | 1728 | 731 | 10310 |
| 756 | 20498 | 765 | 1101 | 763 | 497 | 767 | 1491 | 754 | 762 | 758 | 1815 | 761 | 10809 |
| 786 | 21434 | 795 | 1170 | 793 | 546 | 797 | 1571 | 784 | 818 | 788 | 1902 | 791 | 11311 |
| 816 | 22363 | 825 | 1241 | 823 | 599 | 827 | 1650 | 814 | 875 | 818 | 1988 | 821 | 11810 |
| 846 | 23277 | 855 | 1314 | 853 | 656 | 858 | 1730 | 844 | 935 | 849 | 2074 | 851 | 12303 |
| 876 | 24158 | 885 | 1388 | 883 | 717 | 888 | 1809 | 874 | 997 | 879 | 2159 | 881 | 12779 |
| 906 | 24987 | 915 | 1462 | 913 | 781 | 918 | 1889 | 904 | 1060 | 909 | 2242 | 911 | 13230 |
| 936 | 25752 | 945 | 1538 | 943 | 847 | 948 | 1968 | 934 | 1125 | 939 | 2324 | 941 | 13649 |
| 966 | 26448 | 975 | 1614 | 973 | 914 | 978 | 2048 | 964 | 1190 | 969 | 2405 | 971 | 14033 |
| 996 | 27061 | 1005 | 1690 | 1003 | 983 | 1008 | 2127 | 994 | 1255 | 999 | 2485 | 1001 | 14376 |
| 1026 | 27590 | 1035 | 1764 | 1033 | 1052 | 1039 | 2205 | 1024 | 1319 | 1030 | 2563 | 1031 | 14677 |
| 1056 | 28053 | 1065 | 1837 | 1063 | 1120 | 1069 | 2282 | 1054 | 1382 | 1060 | 2639 | 1061 | 14943 |
| 1086 | 28460 | 1096 | 1911 | 1093 | 1189 | 1099 | 2359 | 1084 | 1445 | 1090 | 2714 | 1091 | 15182 |
| 1116 | 28824 | 1126 | 1983 | 1123 | 1258 | 1129 | 2435 | 1114 | 1507 | 1120 | 2788 | 1121 | 15399 |
| 1146 | 29158 | 1156 | 2054 | 1153 | 1327 | 1159 | 2522 | 1144 | 1569 | 1150 | 2867 | 1151 | 15602 |
| 1176 | 29467 | 1186 | 2124 | 1183 | 1396 | 1189 | 2622 | 1174 | 1631 | 1180 | 2960 | 1181 | 15794 |
| 1206 | 29756 | 1216 | 2194 | 1213 | 1466 | 1220 | 2726 | 1204 | 1693 | 1211 | 3058 | 1212 | 15976 |
| 1236 | 30028 | 1246 | 2264 | 1243 | 1536 | 1250 | 2828 | 1234 | 1756 | 1241 | 3157 | 1242 | 16151 |
| 1266 | 30283 | 1277 | 2332 | 1273 | 1606 | 1280 | 2928 | 1264 | 1817 | 1271 | 3253 | 1272 | 16316 |
| 1296 | 30520 | 1307 | 2400 | 1303 | 1675 | 1310 | 3019 | 1294 | 1877 | 1301 | 3343 | 1302 | 16471 |
| 1326 | 30741 | 1337 | 2466 | 1333 | 1743 | 1340 | 3096 | 1324 | 1936 | 1331 | 3420 | 1332 | 16615 |
| 1356 | 30950 | 1367 | 2530 | 1363 | 1810 | 1370 | 3165 | 1354 | 1995 | 1361 | 3488 | 1362 | 16751 |
| 1386 | 31146 | 1397 | 2595 | 1393 | 1877 | 1401 | 3232 | 1384 | 2052 | 1392 | 3553 | 1392 | 16881 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.15(Suit Seam M_f) + 0.05(Boot Seam M_f) + 0.15(Boot Matl M_f) + 0.1(Crotch M_f) + 0.05(Zipper Matl Interface M_f)

Table F-2. Kappler CPF3 - Average GB Permeation

| Kappler CPF3 Coverall 3T436 | | | | | | | | | | | | | |
|--|-----------|-------------|-----------|-------------|-------------|-------------|-----------|-------------|-----------|-------------|--------|---------------------|---------------------|
| M_f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Matl | Time (min.) | Suit Seam | Time (min.) | Zipper Matl | Time (min.) | Boot Seam | Time (min.) | Boot Matl | Time (min.) | Crotch | Average Time (min.) | Weighted Avg. M_f |
| 3 | 1 | 12 | 3 | 13 | 2 | 14 | 6 | 4 | 1 | 5 | 2 | 9 | 2 |
| 33 | 179 | 42 | 37 | 43 | 23 | 45 | 32 | 34 | 17 | 36 | 39 | 39 | 104 |
| 62 | 462 | 71 | 105 | 73 | 64 | 75 | 65 | 64 | 55 | 66 | 87 | 69 | 270 |
| 92 | 669 | 101 | 190 | 104 | 113 | 105 | 104 | 94 | 111 | 96 | 141 | 99 | 405 |
| 122 | 851 | 131 | 269 | 134 | 161 | 135 | 139 | 125 | 165 | 126 | 191 | 129 | 525 |
| 152 | 1004 | 161 | 341 | 164 | 204 | 165 | 171 | 155 | 215 | 156 | 237 | 159 | 628 |
| 182 | 1141 | 191 | 407 | 194 | 244 | 195 | 194 | 185 | 260 | 186 | 279 | 189 | 720 |
| 212 | 1263 | 221 | 467 | 224 | 281 | 226 | 209 | 215 | 302 | 217 | 311 | 219 | 802 |
| 242 | 1375 | 251 | 525 | 254 | 315 | 256 | 221 | 245 | 341 | 247 | 333 | 249 | 878 |
| 272 | 1477 | 281 | 580 | 285 | 346 | 286 | 233 | 275 | 377 | 277 | 353 | 279 | 946 |
| 302 | 1571 | 311 | 632 | 315 | 374 | 316 | 244 | 306 | 408 | 307 | 372 | 310 | 1010 |
| 332 | 1664 | 341 | 683 | 345 | 400 | 346 | 254 | 336 | 438 | 337 | 390 | 340 | 1072 |
| 362 | 1753 | 371 | 734 | 375 | 426 | 376 | 264 | 366 | 467 | 367 | 407 | 370 | 1132 |
| 392 | 1838 | 401 | 785 | 405 | 451 | 407 | 274 | 396 | 495 | 398 | 423 | 400 | 1190 |
| 422 | 1922 | 431 | 835 | 435 | 475 | 437 | 283 | 426 | 522 | 428 | 440 | 430 | 1246 |
| 452 | 2005 | 461 | 886 | 466 | 499 | 467 | 292 | 456 | 548 | 458 | 456 | 460 | 1303 |
| 482 | 2085 | 491 | 937 | 496 | 522 | 497 | 300 | 487 | 574 | 488 | 471 | 490 | 1357 |
| 512 | 2165 | 521 | 990 | 526 | 546 | 527 | 309 | 517 | 599 | 518 | 486 | 520 | 1412 |
| 542 | 2245 | 551 | 1042 | 556 | 570 | 557 | 316 | 547 | 624 | 548 | 500 | 550 | 1467 |
| 572 | 2327 | 581 | 1095 | 586 | 594 | 588 | 324 | 577 | 649 | 579 | 513 | 581 | 1522 |
| 602 | 2409 | 611 | 1148 | 616 | 620 | 618 | 331 | 607 | 674 | 609 | 526 | 611 | 1578 |
| 632 | 2490 | 641 | 1201 | 647 | 647 | 648 | 338 | 638 | 700 | 639 | 538 | 641 | 1633 |
| 662 | 2570 | 671 | 1254 | 677 | 676 | 678 | 344 | 668 | 727 | 669 | 549 | 671 | 1688 |
| 692 | 2650 | 701 | 1306 | 707 | 704 | 708 | 349 | 698 | 754 | 699 | 560 | 701 | 1743 |
| 722 | 2730 | 731 | 1358 | 737 | 734 | 738 | 353 | 728 | 780 | 729 | 571 | 731 | 1797 |
| 752 | 2809 | 761 | 1409 | 767 | 764 | 769 | 355 | 758 | 808 | 760 | 581 | 761 | 1851 |
| 782 | 2888 | 791 | 1459 | 798 | 795 | 799 | 357 | 788 | 835 | 790 | 591 | 791 | 1905 |
| 812 | 2966 | 821 | 1509 | 828 | 828 | 829 | 359 | 819 | 863 | 820 | 601 | 822 | 1958 |
| 842 | 3043 | 851 | 1557 | 858 | 860 | 859 | 361 | 849 | 891 | 850 | 610 | 852 | 2011 |
| 872 | 3119 | 881 | 1605 | 888 | 892 | 889 | 363 | 879 | 919 | 880 | 620 | 882 | 2063 |
| 902 | 3194 | 911 | 1652 | 918 | 925 | 919 | 365 | 909 | 947 | 910 | 629 | 912 | 2114 |
| 932 | 3268 | 941 | 1697 | 948 | 957 | 950 | 366 | 939 | 975 | 941 | 638 | 942 | 2165 |
| 963 | 3340 | 972 | 1741 | 979 | 990 | 980 | 367 | 970 | 1002 | 971 | 647 | 973 | 2214 |
| 993 | 3411 | 1002 | 1784 | 1009 | 1024 | 1010 | 368 | 1000 | 1030 | 1001 | 655 | 1003 | 2263 |
| 1023 | 3481 | 1032 | 1826 | 1039 | 1059 | 1040 | 369 | 1030 | 1059 | 1031 | 664 | 1033 | 2311 |
| 1053 | 3549 | 1062 | 1868 | 1069 | 1094 | 1070 | 371 | 1060 | 1088 | 1061 | 673 | 1063 | 2358 |
| 1083 | 3616 | 1092 | 1908 | 1099 | 1127 | 1100 | 372 | 1090 | 1116 | 1091 | 682 | 1093 | 2405 |
| 1113 | 3680 | 1122 | 1947 | 1130 | 1160 | 1131 | 372 | 1121 | 1144 | 1122 | 690 | 1123 | 2449 |
| 1144 | 3743 | 1153 | 1984 | 1160 | 1191 | 1161 | 372 | 1151 | 1171 | 1152 | 699 | 1154 | 2493 |
| 1174 | 3804 | 1183 | 2020 | 1190 | 1223 | 1191 | 372 | 1181 | 1198 | 1182 | 708 | 1184 | 2535 |
| 1204 | 3862 | 1213 | 2055 | 1220 | 1254 | 1221 | 372 | 1211 | 1224 | 1212 | 716 | 1214 | 2576 |
| 1234 | 3918 | 1243 | 2088 | 1250 | 1285 | 1251 | 372 | 1241 | 1250 | 1242 | 724 | 1244 | 2615 |
| 1264 | 3972 | 1273 | 2119 | 1281 | 1315 | 1281 | 372 | 1272 | 1276 | 1272 | 733 | 1274 | 2653 |
| 1294 | 4025 | 1303 | 2150 | 1311 | 1343 | 1312 | 372 | 1302 | 1301 | 1303 | 741 | 1304 | 2690 |
| 1325 | 4078 | 1334 | 2180 | 1341 | 1371 | 1342 | 372 | 1332 | 1326 | 1333 | 749 | 1335 | 2727 |
| 1355 | 4131 | 1364 | 2209 | 1371 | 1397 | 1372 | 372 | 1362 | 1348 | 1363 | 757 | 1365 | 2763 |
| 1385 | 4184 | 1394 | 2238 | 1401 | 1425 | 1402 | 372 | 1392 | 1373 | 1393 | 766 | 1395 | 2800 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: $Wtd\ Avg\ M_f = 0.5(\text{Suit Matl } M_f) + 0.15(\text{Suit Seam } M_f) + 0.05(\text{Boot Seam } M_f) + 0.15(\text{Boot Matl } M_f) + 0.1(\text{Crotch } M_f) + 0.05(\text{Zipper Matl Interface } M_f)$

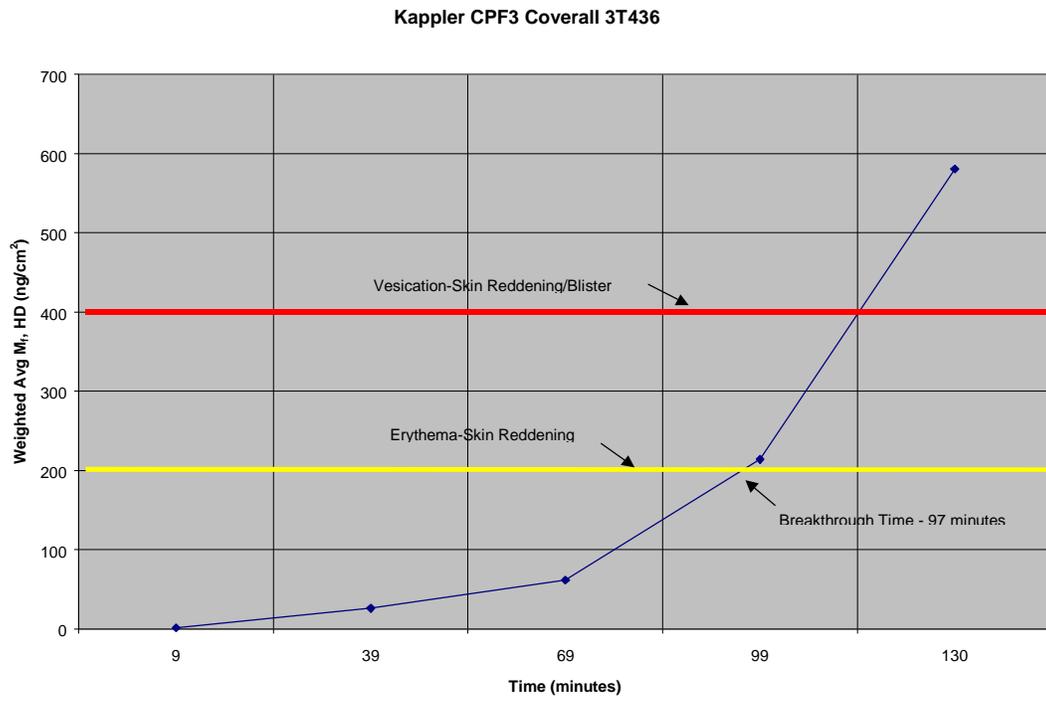


Figure F-3: Kappler CPF3 - Weighted Average HD Permeation

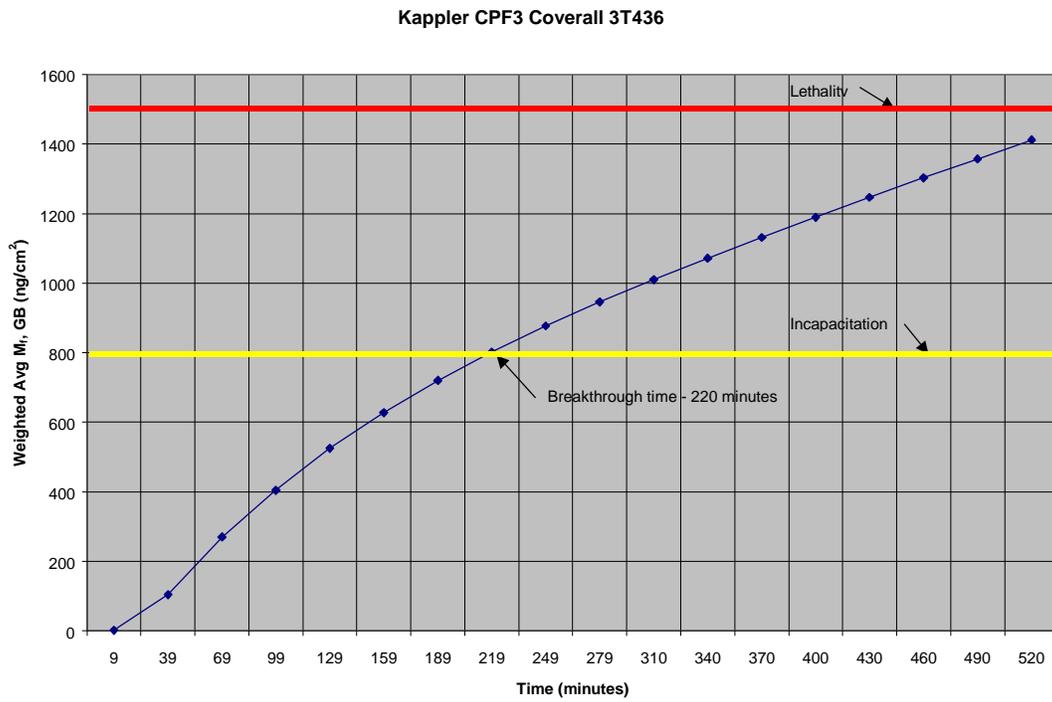


Figure F-4: Kappler CPF3 - Weighted Average GB Permeation

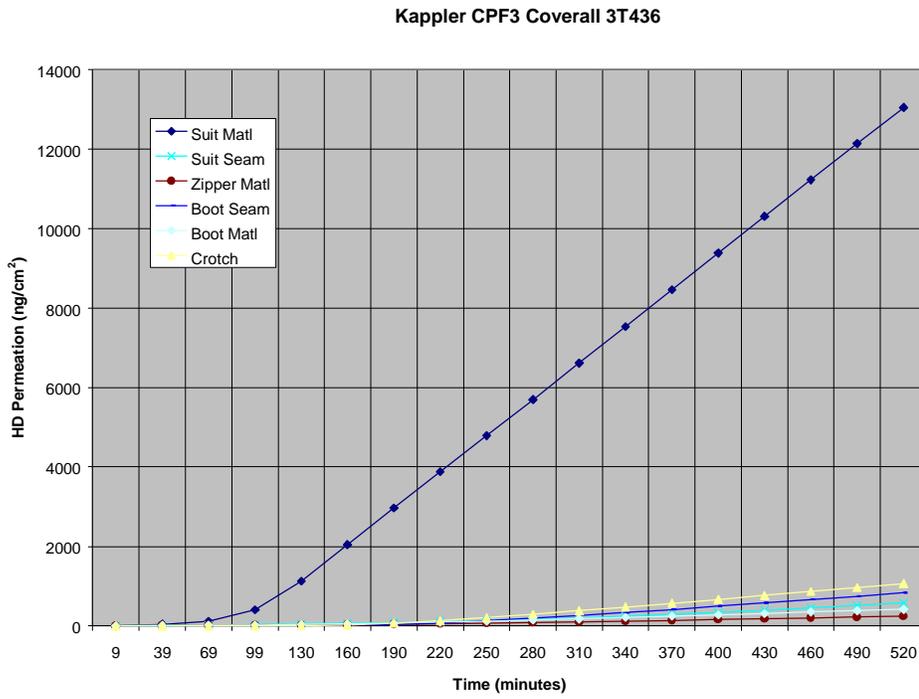


Figure F-5: Kappler CPF3: HD Permeation By Sampling Area

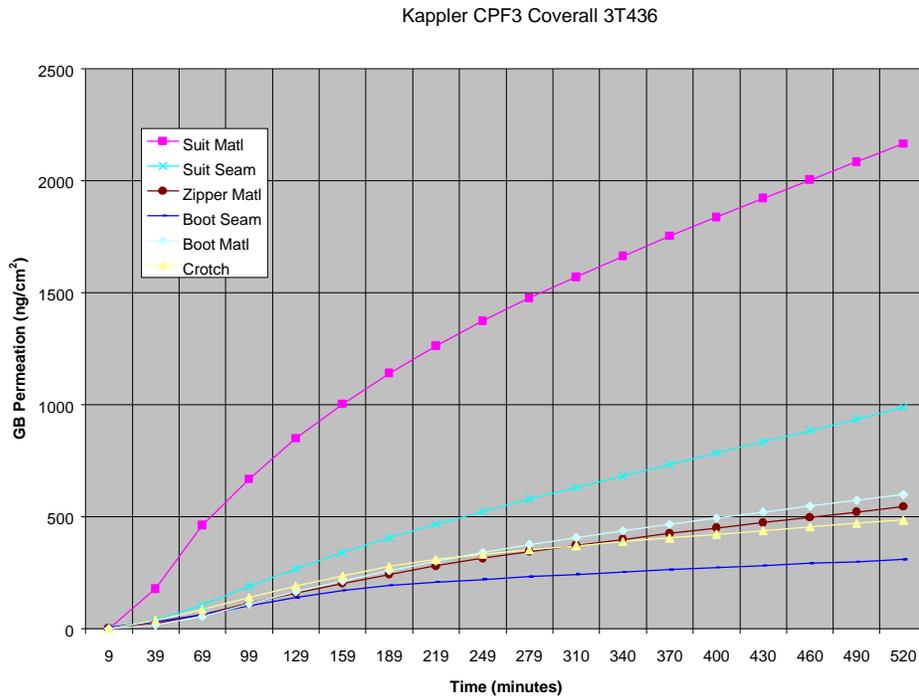


Figure F-6: Kappler CPF3: GB Permeation By Sampling Area

Table F-3. Kappler CPF3 Coverall 3T436 - System Test (Aerosol Simulant) Results

| PF Range | Visor Region and Upper Arm, Combined | | | | | |
|---------------|--------------------------------------|--------------------------|-------------------------------|---------------------------|--------------------------|-------------------------------|
| | Pre-Operational Exercises | | | Operational Exercises | | |
| | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent |
| 0-9 | 24 | 100 | 0 | 24 | 100 | 0 |
| 10-49 | 0 | 100 | 0 | 0 | 100 | 0 |
| 50-99 | 0 | 100 | 0 | 0 | 100 | 0 |
| 100-499 | 0 | 100 | 0 | 0 | 100 | 0 |
| 500-999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 1000-1666 | 0 | 100 | 0 | 0 | 100 | 0 |
| 1667-4999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 5000-6666 | 0 | 100 | 0 | 0 | 100 | 0 |
| 6667-9999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 10000-19999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 20000-49999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 50000-99999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 100000+ | 0 | 100 | 0 | 0 | 100 | 0 |
| No. of Trials | 24 | | | 24 | | |

Table F-4. Kappler CPF3 Coverall 3T436 - Overall Test Results

| Breakthrough Time (minutes) | | Aerosol PF Pass Rate at PF Equal to: | | | Exercise Phase |
|-----------------------------|----------|--------------------------------------|-----|-----|-----------------|
| Incapacitation | Erythema | 10 | 50 | 100 | |
| GB | HD | | | | |
| 220 | 97 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | 0.0 | 0.0 | 0.0 | Operational |



Figure G-1: MarMac Tyvek/Saranex 23-P Coverall - Front View



Figure G-2: MarMac Tyvek/Saranex 23-P Coverall - Side View

Table G-1. MarMac Tyvek/Saranex - Average HD Permeation

| MarMac Tyvek/Saranex 23-P Coverall | | | | | | | | | | | | | |
|---|-----------|-------------|-----------|-------------|-------------|-------------|-----------|-------------|-----------|-------------|--------|---------------------|------------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Matl | Time (min.) | Suit Seam | Time (min.) | Zipper Matl | Time (min.) | Boot Seam | Time (min.) | Boot Matl | Time (min.) | Crotch | Average Time (min.) | Weighted Avg. M _f |
| 6 | 1 | 15 | 7 | 13 | 5 | 5 | 7 | 4 | 2 | 14 | 14 | 10 | 4 |
| 36 | 43 | 45 | 74 | 43 | 374 | 35 | 411 | 34 | 23 | 44 | 351 | 40 | 110 |
| 66 | 109 | 75 | 214 | 73 | 996 | 65 | 1176 | 64 | 76 | 74 | 994 | 70 | 306 |
| 96 | 407 | 105 | 585 | 103 | 1526 | 96 | 1960 | 94 | 570 | 105 | 1726 | 100 | 724 |
| 126 | 1131 | 135 | 1314 | 133 | 2168 | 126 | 2741 | 124 | 1516 | 135 | 2512 | 130 | 1487 |
| 156 | 2049 | 165 | 2216 | 163 | 3009 | 156 | 3512 | 154 | 2509 | 165 | 3293 | 160 | 2389 |
| 186 | 2970 | 195 | 3129 | 193 | 3960 | 186 | 4277 | 184 | 3499 | 195 | 4065 | 190 | 3298 |
| 216 | 3880 | 225 | 4041 | 223 | 4943 | 216 | 5045 | 214 | 4485 | 225 | 4837 | 220 | 4202 |
| 246 | 4785 | 255 | 4949 | 253 | 5934 | 246 | 5812 | 244 | 5477 | 255 | 5609 | 250 | 5105 |
| 276 | 5695 | 285 | 5857 | 283 | 6917 | 277 | 6576 | 274 | 6466 | 286 | 6377 | 280 | 6008 |
| 306 | 6610 | 315 | 6773 | 313 | 7871 | 307 | 7337 | 304 | 7424 | 316 | 7143 | 310 | 6909 |
| 336 | 7534 | 345 | 7695 | 343 | 8819 | 337 | 8095 | 334 | 8373 | 346 | 7907 | 340 | 7814 |
| 366 | 8459 | 375 | 8617 | 373 | 9791 | 367 | 8851 | 364 | 9342 | 376 | 8671 | 370 | 8723 |
| 396 | 9384 | 405 | 9539 | 403 | 10769 | 397 | 9606 | 394 | 10323 | 406 | 9436 | 400 | 9634 |
| 426 | 10307 | 435 | 10459 | 433 | 11751 | 427 | 10362 | 424 | 11308 | 436 | 10200 | 430 | 10544 |
| 456 | 11224 | 465 | 11370 | 463 | 12730 | 458 | 11116 | 454 | 12294 | 467 | 10962 | 461 | 11450 |
| 486 | 12134 | 495 | 12278 | 493 | 13710 | 488 | 11868 | 484 | 13283 | 497 | 11724 | 491 | 12352 |
| 516 | 13044 | 525 | 13188 | 523 | 14694 | 518 | 12621 | 514 | 14270 | 527 | 12486 | 521 | 13255 |
| 546 | 13961 | 555 | 14104 | 553 | 15679 | 548 | 13381 | 544 | 15258 | 557 | 13254 | 551 | 14163 |
| 576 | 14885 | 585 | 15028 | 583 | 16666 | 578 | 14144 | 574 | 16247 | 587 | 14027 | 581 | 15077 |
| 606 | 15811 | 615 | 15950 | 613 | 17666 | 608 | 14909 | 604 | 17237 | 617 | 14800 | 611 | 15992 |
| 636 | 16740 | 645 | 16873 | 643 | 18670 | 639 | 15680 | 634 | 18212 | 648 | 15577 | 641 | 16908 |
| 666 | 17677 | 675 | 17805 | 673 | 19673 | 669 | 16452 | 664 | 19153 | 678 | 16355 | 671 | 17824 |
| 696 | 18623 | 705 | 18745 | 703 | 20676 | 699 | 17217 | 694 | 20057 | 708 | 17129 | 701 | 18739 |
| 726 | 19564 | 735 | 19685 | 733 | 21675 | 729 | 17978 | 724 | 20925 | 738 | 17910 | 731 | 19647 |
| 756 | 20498 | 765 | 20626 | 763 | 22670 | 759 | 18732 | 754 | 21763 | 768 | 18700 | 761 | 20547 |
| 786 | 21434 | 795 | 21569 | 793 | 23670 | 789 | 19457 | 784 | 22582 | 798 | 19488 | 791 | 21445 |
| 816 | 22363 | 825 | 22515 | 823 | 24673 | 820 | 20144 | 814 | 23385 | 829 | 20276 | 821 | 22335 |
| 846 | 23277 | 855 | 23460 | 853 | 25670 | 850 | 20791 | 844 | 24163 | 859 | 21062 | 851 | 23211 |
| 876 | 24158 | 885 | 24400 | 883 | 26658 | 880 | 21395 | 874 | 24912 | 889 | 21835 | 881 | 24062 |
| 906 | 24987 | 915 | 25339 | 913 | 27647 | 910 | 21947 | 904 | 25626 | 919 | 22601 | 911 | 24878 |
| 936 | 25752 | 945 | 26276 | 944 | 28640 | 940 | 22441 | 935 | 26295 | 949 | 23359 | 942 | 25652 |
| 966 | 26448 | 975 | 27200 | 974 | 29630 | 970 | 22883 | 965 | 26906 | 979 | 24099 | 972 | 26375 |
| 996 | 27061 | 1005 | 28100 | 1004 | 30612 | 1001 | 23285 | 995 | 27452 | 1010 | 24814 | 1002 | 27040 |
| 1026 | 27590 | 1035 | 28973 | 1034 | 31581 | 1031 | 23655 | 1025 | 27920 | 1040 | 25499 | 1032 | 27641 |
| 1056 | 28053 | 1065 | 29805 | 1064 | 32539 | 1061 | 24000 | 1055 | 28312 | 1070 | 26155 | 1062 | 28187 |
| 1086 | 28460 | 1095 | 30584 | 1094 | 33491 | 1091 | 24326 | 1085 | 28641 | 1100 | 26791 | 1092 | 28684 |
| 1116 | 28824 | 1125 | 31322 | 1125 | 34432 | 1121 | 24633 | 1116 | 28919 | 1130 | 27397 | 1122 | 29141 |
| 1146 | 29158 | 1155 | 32013 | 1155 | 35359 | 1151 | 24926 | 1146 | 29158 | 1160 | 27968 | 1152 | 29566 |
| 1176 | 29467 | 1185 | 32652 | 1185 | 36275 | 1182 | 25208 | 1176 | 29369 | 1191 | 28516 | 1183 | 29962 |
| 1206 | 29756 | 1215 | 33245 | 1215 | 37175 | 1212 | 25479 | 1206 | 29559 | 1221 | 29039 | 1213 | 30335 |
| 1236 | 30028 | 1245 | 33795 | 1245 | 38058 | 1242 | 25741 | 1236 | 29736 | 1251 | 29537 | 1243 | 30687 |
| 1266 | 30283 | 1275 | 34312 | 1275 | 38924 | 1272 | 26000 | 1266 | 29900 | 1281 | 30016 | 1273 | 31021 |
| 1296 | 30520 | 1305 | 34797 | 1306 | 39780 | 1302 | 26253 | 1297 | 30055 | 1311 | 30484 | 1303 | 31338 |
| 1326 | 30741 | 1335 | 35254 | 1336 | 40628 | 1332 | 26500 | 1327 | 30204 | 1341 | 30942 | 1333 | 31640 |
| 1356 | 30950 | 1365 | 35690 | 1366 | 41464 | 1363 | 26740 | 1357 | 30347 | 1372 | 31387 | 1363 | 31929 |
| 1386 | 31146 | 1395 | 36106 | 1396 | 42289 | 1393 | 26980 | 1387 | 30487 | 1402 | 31819 | 1393 | 32207 |
| 1416 | 31328 | 1425 | 36510 | 1426 | 43104 | 1423 | 27222 | 1417 | 30624 | 1432 | 32255 | 1423 | 32476 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.15(Suit Seam M_f) + 0.05(Boot Seam M_f) + 0.15(Boot Matl M_f) + 0.1(Crotch M_f) + 0.05(Zipper Matl Interface M_f)

Table G-2. MarMac Tyvek/Saranex - Average GB Permeation

| MarMac Tyvek/Saranex 23-P Coverall | | | | | | | | | | | | | |
|---|---------------|-------------|-----------|-------------|-----------------|-------------|-----------|-------------|---------------|-------------|--------|--------------------|-----------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Material | Time (min.) | Suit Seam | Time (min.) | Zipper Material | Time (min.) | Boot Seam | Time (min.) | Boot Material | Time (min.) | Crotch | Average Time (min) | Weighted Avg M _f |
| 5 | 3 | 14 | 8 | 12 | 1 | 6 | 1 | 3 | 0 | 15 | 0 | 9 | 3 |
| 36 | 28 | 45 | 215 | 43 | 36 | 36 | 72 | 33 | 32 | 45 | 60 | 40 | 62 |
| 66 | 71 | 75 | 608 | 73 | 102 | 66 | 284 | 64 | 105 | 76 | 281 | 70 | 190 |
| 96 | 135 | 105 | 1031 | 103 | 152 | 97 | 617 | 94 | 186 | 106 | 640 | 100 | 353 |
| 126 | 195 | 135 | 1490 | 133 | 193 | 127 | 1014 | 124 | 254 | 136 | 1049 | 130 | 524 |
| 156 | 246 | 165 | 1965 | 163 | 243 | 157 | 1441 | 154 | 311 | 166 | 1480 | 160 | 697 |
| 186 | 292 | 195 | 2448 | 193 | 289 | 187 | 1889 | 184 | 363 | 196 | 1930 | 190 | 870 |
| 217 | 334 | 226 | 2940 | 224 | 330 | 217 | 2352 | 214 | 410 | 226 | 2392 | 221 | 1043 |
| 247 | 374 | 256 | 3436 | 254 | 362 | 247 | 2825 | 245 | 442 | 257 | 2858 | 251 | 1214 |
| 277 | 411 | 286 | 3934 | 284 | 385 | 278 | 3309 | 275 | 456 | 287 | 3326 | 281 | 1381 |
| 307 | 447 | 316 | 4432 | 314 | 412 | 308 | 3799 | 305 | 475 | 317 | 3793 | 311 | 1549 |
| 337 | 480 | 346 | 4929 | 344 | 443 | 338 | 4289 | 335 | 509 | 347 | 4256 | 341 | 1718 |
| 367 | 512 | 376 | 5424 | 374 | 474 | 368 | 4781 | 365 | 542 | 377 | 4719 | 371 | 1886 |
| 398 | 543 | 407 | 5921 | 405 | 505 | 398 | 5271 | 395 | 576 | 407 | 5185 | 402 | 2053 |
| 428 | 573 | 437 | 6419 | 435 | 536 | 428 | 5763 | 426 | 609 | 438 | 5652 | 432 | 2221 |
| 458 | 603 | 467 | 6914 | 465 | 566 | 459 | 6255 | 456 | 643 | 468 | 6114 | 462 | 2388 |
| 488 | 631 | 497 | 7408 | 495 | 596 | 489 | 6747 | 486 | 675 | 498 | 6575 | 492 | 2553 |
| 518 | 658 | 527 | 7901 | 525 | 625 | 519 | 7241 | 516 | 705 | 528 | 7031 | 522 | 2716 |
| 548 | 685 | 557 | 8393 | 555 | 652 | 549 | 7737 | 546 | 735 | 558 | 7481 | 552 | 2879 |
| 579 | 711 | 588 | 8884 | 586 | 679 | 579 | 8233 | 576 | 764 | 588 | 7921 | 583 | 3040 |
| 609 | 737 | 618 | 9376 | 616 | 706 | 609 | 8727 | 607 | 792 | 619 | 8351 | 613 | 3200 |
| 639 | 762 | 648 | 9867 | 646 | 733 | 640 | 9224 | 637 | 821 | 649 | 8772 | 643 | 3359 |
| 669 | 787 | 678 | 10357 | 676 | 758 | 670 | 9722 | 667 | 848 | 679 | 9187 | 673 | 3517 |
| 699 | 811 | 708 | 10848 | 706 | 784 | 700 | 10216 | 697 | 875 | 709 | 9597 | 703 | 3674 |
| 729 | 835 | 738 | 11337 | 736 | 809 | 730 | 10710 | 727 | 903 | 739 | 10049 | 733 | 3834 |
| 760 | 858 | 769 | 11820 | 767 | 832 | 760 | 11204 | 757 | 928 | 769 | 10545 | 764 | 3998 |
| 790 | 880 | 799 | 12302 | 797 | 856 | 790 | 11700 | 788 | 953 | 800 | 11041 | 794 | 4160 |
| 820 | 903 | 829 | 12783 | 827 | 878 | 821 | 12197 | 818 | 977 | 830 | 11539 | 824 | 4323 |
| 850 | 925 | 859 | 13258 | 857 | 900 | 851 | 12694 | 848 | 1001 | 860 | 12041 | 854 | 4485 |
| 880 | 946 | 889 | 13731 | 887 | 921 | 881 | 13194 | 878 | 1024 | 890 | 12540 | 884 | 4646 |
| 910 | 967 | 919 | 14207 | 917 | 941 | 911 | 13690 | 908 | 1045 | 920 | 13037 | 914 | 4807 |
| 941 | 988 | 950 | 14680 | 948 | 961 | 941 | 14183 | 938 | 1067 | 950 | 13539 | 945 | 4967 |
| 971 | 1009 | 980 | 15151 | 978 | 980 | 971 | 14678 | 969 | 1088 | 981 | 14044 | 975 | 5128 |
| 1001 | 1028 | 1010 | 15618 | 1008 | 1000 | 1002 | 15173 | 999 | 1108 | 1011 | 14548 | 1005 | 5286 |
| 1031 | 1047 | 1040 | 16083 | 1038 | 1018 | 1032 | 15662 | 1029 | 1128 | 1041 | 15053 | 1035 | 5444 |
| 1061 | 1066 | 1070 | 16544 | 1068 | 1037 | 1062 | 16147 | 1059 | 1147 | 1071 | 15559 | 1065 | 5602 |
| 1091 | 1085 | 1100 | 17000 | 1098 | 1054 | 1092 | 16632 | 1089 | 1166 | 1101 | 16066 | 1095 | 5758 |
| 1122 | 1102 | 1131 | 17454 | 1129 | 1072 | 1122 | 17117 | 1119 | 1184 | 1131 | 16577 | 1126 | 5914 |
| 1152 | 1120 | 1161 | 17902 | 1159 | 1089 | 1152 | 17600 | 1150 | 1203 | 1162 | 17088 | 1156 | 6069 |
| 1182 | 1137 | 1191 | 18341 | 1189 | 1106 | 1183 | 18080 | 1180 | 1222 | 1192 | 17598 | 1186 | 6222 |
| 1212 | 1154 | 1221 | 18776 | 1219 | 1122 | 1213 | 18555 | 1210 | 1239 | 1222 | 18107 | 1216 | 6374 |
| 1242 | 1170 | 1251 | 19208 | 1249 | 1139 | 1243 | 19028 | 1240 | 1256 | 1252 | 18620 | 1246 | 6525 |
| 1272 | 1186 | 1281 | 19631 | 1279 | 1154 | 1273 | 19501 | 1270 | 1273 | 1282 | 19133 | 1276 | 6675 |
| 1303 | 1201 | 1312 | 20046 | 1310 | 1170 | 1303 | 19971 | 1300 | 1290 | 1312 | 19645 | 1307 | 6822 |
| 1333 | 1216 | 1342 | 20456 | 1340 | 1186 | 1334 | 20427 | 1331 | 1307 | 1343 | 20093 | 1337 | 6962 |
| 1363 | 1232 | 1372 | 20862 | 1370 | 1201 | 1364 | 20863 | 1361 | 1323 | 1373 | 20465 | 1367 | 7093 |
| 1393 | 1247 | 1402 | 21263 | 1400 | 1216 | 1394 | 21286 | 1391 | 1338 | 1403 | 20817 | 1397 | 7220 |
| 1423 | 1261 | 1432 | 21660 | 1430 | 1229 | 1424 | 21697 | 1421 | 1352 | 1433 | 21155 | 1427 | 7344 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.15(Suit Seam M_f) + 0.05(Boot Seam M_f) + 0.15(Boot Matl M_f) + 0.1(Crotch M_f) + 0.05(Zipper Matl Interface M_f)

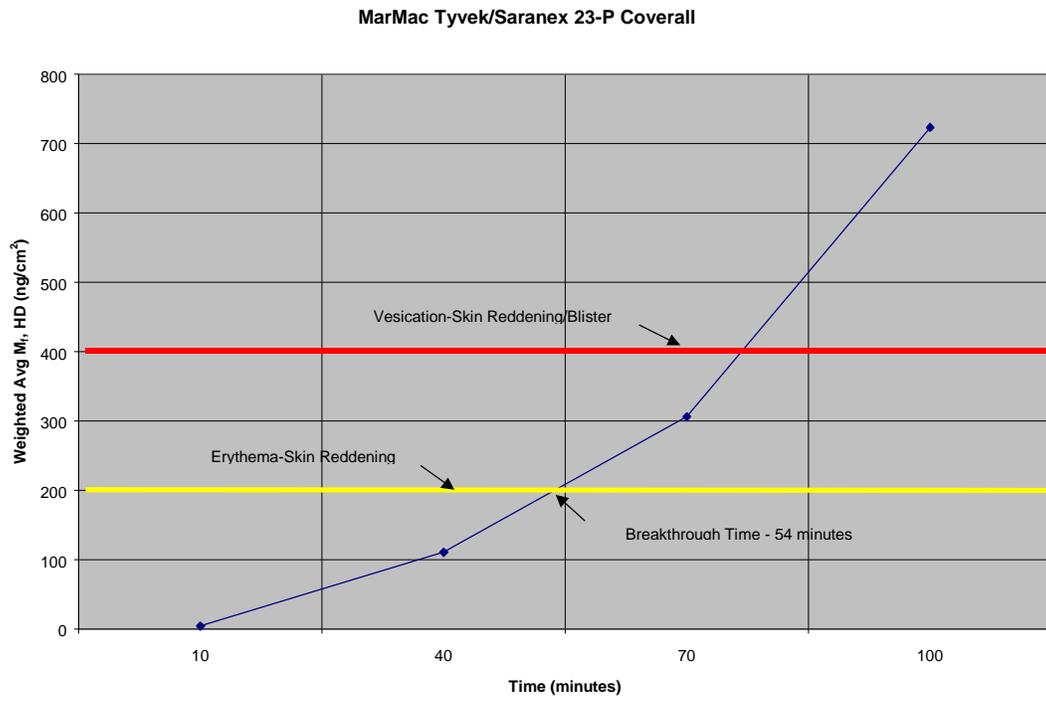


Figure G-3: MarMac Tyvek/Saranex- Weighted Average HD Permeation

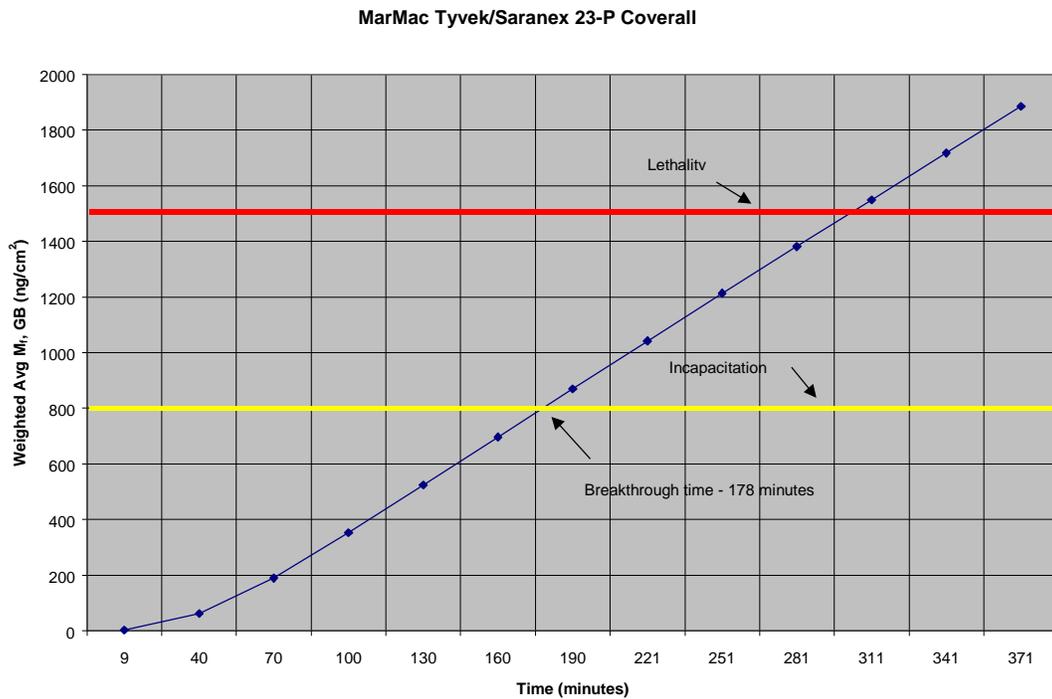


Figure G-4: MarMac Tyvek/Saranex - Weighted Average GB Permeation

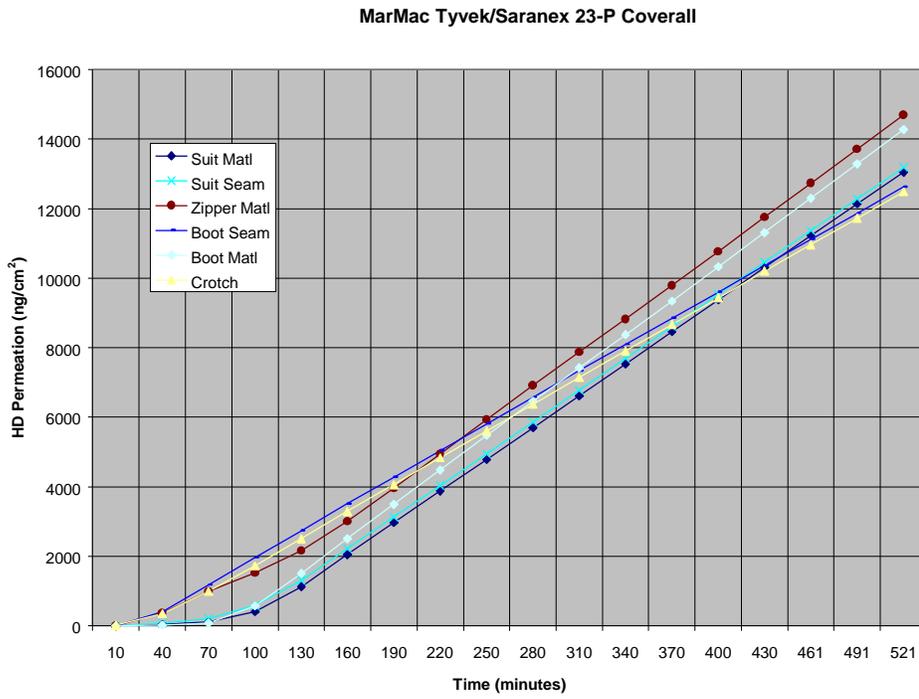


Figure G-5: MarMac Tyvek/Saranex - HD Permeation by Sampling Area

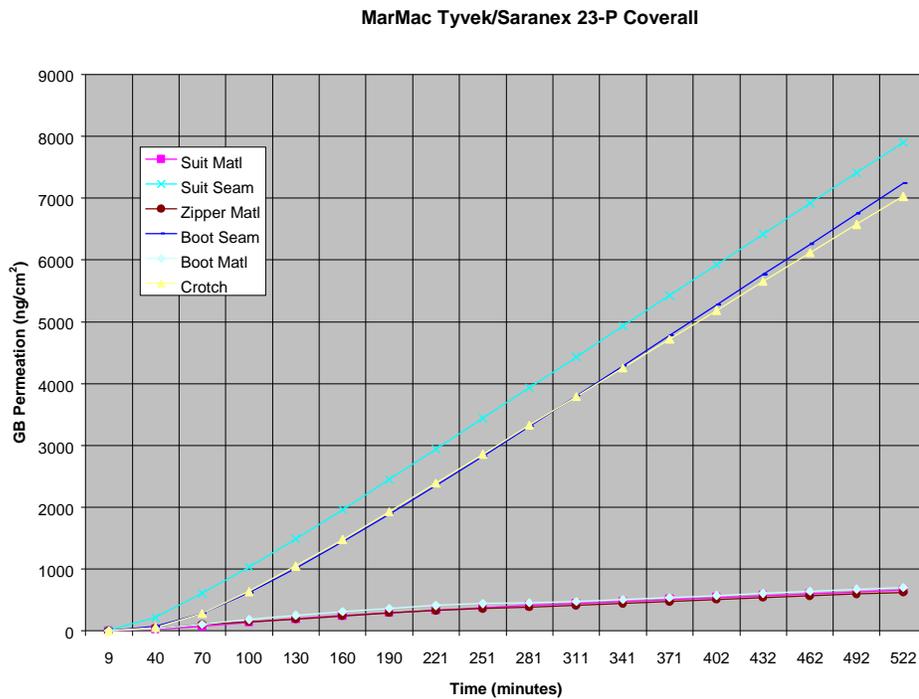


Figure G-6: MarMac Tyvek/Saranex - GB Permeation by Sampling Area

Table G-3. MarMac Tyvek/Saranex 23-P Coverall - System Test (Aerosol Simulant) Results

| PF Range | Visor Region and Upper Arm, Combined | | | | | |
|---------------|--------------------------------------|--------------------------|-------------------------------|---------------------------|--------------------------|-------------------------------|
| | Pre-Operational Exercises | | | Operational Exercises | | |
| | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent |
| 0-9 | 24 | 100 | 0 | 24 | 100 | 0 |
| 10-49 | 0 | 100 | 0 | 0 | 100 | 0 |
| 50-99 | 0 | 100 | 0 | 0 | 100 | 0 |
| 100-499 | 0 | 100 | 0 | 0 | 100 | 0 |
| 500-999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 1000-1666 | 0 | 100 | 0 | 0 | 100 | 0 |
| 1667-4999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 5000-6666 | 0 | 100 | 0 | 0 | 100 | 0 |
| 6667-9999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 10000-19999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 20000-49999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 50000-99999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 100000+ | 0 | 100 | 0 | 0 | 100 | 0 |
| No. of Trials | 24 | | | 24 | | |

Note: Five of eight suits tore during testing. The material generally tore at the stitched seams in the crotch and underarm areas. The suits were repaired with duct tape and were used for the remainder of the study.

Table G-4. MarMac Tyvek/Saranex 23-P Coverall - Overall Test Results

| Breakthrough Time (minutes) | | Aerosol PF Pass Rate at PF Equal to: | | | Exercise Phase |
|-----------------------------|----------|--------------------------------------|-----|-----|-----------------|
| Incapacitation | Erythema | 10 | 50 | 100 | |
| GB | HD | | | | |
| 178 | 54 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | 0.0 | 0.0 | 0.0 | Operational |



**Figure H-1: ILC Dover Model 16-51 Coverall-
Front View**



**Figure H-2: ILC Dover Model 16-51 Coverall-
Side View**

Table H-1. ILC Dover Model 16-51 - Average HD Permeation

| ILC Dover Model 16-51 Coverall | | | | | | | | | | | | | |
|---|---------------|-------------|-----------|-------------|-----------------|-------------|--------------|-------------|---------------|-------------|--------|---------------------|-----------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Material | Time (min.) | Suit Seam | Time (min.) | Zipper Material | Time (min.) | Outer Zipper | Time (min.) | Hood Material | Time (min.) | Crotch | Average Time (min.) | Weighted Avg M _f |
| 2 | 1 | 11 | 5 | 15 | 16 | 6 | 6 | 15 | 13 | 6 | 1 | 9 | 4 |
| 32 | 85 | 41 | 40 | 45 | 157 | 36 | 60 | 45 | 457 | 36 | 365 | 39 | 164 |
| 62 | 417 | 71 | 321 | 76 | 512 | 66 | 115 | 76 | 1328 | 67 | 1232 | 70 | 610 |
| 92 | 941 | 101 | 845 | 106 | 1002 | 97 | 397 | 106 | 2245 | 97 | 2266 | 100 | 1231 |
| 122 | 1475 | 131 | 1371 | 136 | 1493 | 127 | 895 | 137 | 3227 | 128 | 3321 | 130 | 1879 |
| 152 | 2004 | 161 | 1903 | 166 | 1986 | 157 | 1397 | 167 | 4269 | 158 | 4372 | 160 | 2534 |
| 182 | 2532 | 191 | 2439 | 196 | 2482 | 187 | 1899 | 197 | 5308 | 188 | 5421 | 190 | 3189 |
| 212 | 3066 | 221 | 2978 | 227 | 2980 | 218 | 2401 | 228 | 6340 | 218 | 6473 | 221 | 3847 |
| 242 | 3601 | 251 | 3517 | 257 | 3478 | 248 | 2903 | 258 | 7370 | 249 | 7524 | 251 | 4505 |
| 272 | 4137 | 281 | 4056 | 287 | 3979 | 278 | 3407 | 288 | 8403 | 279 | 8572 | 281 | 5164 |
| 302 | 4676 | 311 | 4596 | 318 | 4485 | 308 | 3913 | 319 | 9435 | 310 | 9622 | 311 | 5825 |
| 332 | 5215 | 341 | 5135 | 348 | 4995 | 339 | 4424 | 349 | 10475 | 340 | 10670 | 342 | 6487 |
| 362 | 5755 | 371 | 5676 | 378 | 5506 | 369 | 4938 | 379 | 11519 | 370 | 11723 | 372 | 7151 |
| 392 | 6296 | 401 | 6219 | 408 | 6018 | 399 | 5453 | 410 | 12562 | 401 | 12776 | 402 | 7816 |
| 422 | 6843 | 431 | 6762 | 439 | 6534 | 430 | 5968 | 440 | 13608 | 431 | 13828 | 432 | 8485 |
| 452 | 7391 | 461 | 7306 | 469 | 7051 | 460 | 6486 | 470 | 14655 | 461 | 14880 | 462 | 9155 |
| 482 | 7938 | 491 | 7850 | 499 | 7568 | 490 | 7005 | 501 | 15700 | 492 | 15933 | 493 | 9823 |
| 512 | 8485 | 521 | 8397 | 529 | 8084 | 520 | 7523 | 531 | 16748 | 522 | 16987 | 523 | 10493 |
| 542 | 9030 | 551 | 8943 | 560 | 8600 | 551 | 8042 | 561 | 17795 | 552 | 18040 | 553 | 11162 |
| 572 | 9576 | 581 | 9490 | 590 | 9117 | 581 | 8562 | 592 | 18850 | 583 | 19094 | 583 | 11832 |
| 602 | 10127 | 611 | 10038 | 620 | 9633 | 611 | 9081 | 622 | 19914 | 613 | 20157 | 613 | 12508 |
| 632 | 10677 | 641 | 10588 | 650 | 10150 | 641 | 9601 | 652 | 20972 | 643 | 21222 | 643 | 13182 |
| 662 | 11230 | 671 | 11139 | 681 | 10664 | 672 | 10119 | 683 | 22031 | 674 | 22285 | 674 | 13858 |
| 692 | 11787 | 701 | 11692 | 711 | 11177 | 702 | 10635 | 713 | 23094 | 704 | 23351 | 704 | 14537 |
| 723 | 12349 | 732 | 12252 | 741 | 11690 | 732 | 11150 | 743 | 24157 | 734 | 24417 | 734 | 15220 |
| 753 | 12917 | 762 | 12814 | 772 | 12204 | 763 | 11665 | 774 | 25221 | 765 | 25484 | 765 | 15906 |
| 783 | 13486 | 792 | 13377 | 802 | 12717 | 793 | 12181 | 804 | 26282 | 795 | 26552 | 795 | 16592 |
| 814 | 14055 | 823 | 13942 | 832 | 13231 | 823 | 12697 | 834 | 27342 | 825 | 27621 | 825 | 17279 |
| 844 | 14622 | 853 | 14507 | 863 | 13744 | 854 | 13213 | 865 | 28402 | 856 | 28687 | 856 | 17964 |
| 874 | 15186 | 883 | 15072 | 893 | 14256 | 884 | 13726 | 895 | 29458 | 886 | 29748 | 886 | 18646 |
| 905 | 15749 | 914 | 15637 | 923 | 14768 | 914 | 14238 | 925 | 30513 | 916 | 30810 | 916 | 19328 |
| 935 | 16315 | 944 | 16201 | 954 | 15278 | 945 | 14748 | 956 | 31580 | 947 | 31878 | 947 | 20014 |
| 965 | 16882 | 974 | 16768 | 984 | 15790 | 975 | 15260 | 986 | 32655 | 977 | 32950 | 977 | 20702 |
| 995 | 17453 | 1005 | 17337 | 1014 | 16302 | 1005 | 15775 | 1016 | 33727 | 1007 | 34026 | 1007 | 21393 |
| 1026 | 18024 | 1035 | 17904 | 1045 | 16816 | 1035 | 16290 | 1047 | 34797 | 1038 | 35108 | 1038 | 22083 |
| 1056 | 18596 | 1065 | 18472 | 1075 | 17329 | 1066 | 16803 | 1077 | 35863 | 1068 | 36189 | 1068 | 22774 |
| 1086 | 19171 | 1096 | 19042 | 1105 | 17843 | 1096 | 17316 | 1107 | 36925 | 1098 | 37266 | 1098 | 23465 |
| 1117 | 19745 | 1126 | 19611 | 1136 | 18357 | 1126 | 17829 | 1138 | 37988 | 1129 | 38343 | 1129 | 24156 |
| 1147 | 20314 | 1156 | 20177 | 1166 | 18866 | 1157 | 18338 | 1168 | 39054 | 1159 | 39425 | 1159 | 24844 |
| 1177 | 20878 | 1187 | 20740 | 1196 | 19376 | 1187 | 18845 | 1198 | 40123 | 1189 | 40508 | 1189 | 25530 |
| 1208 | 21444 | 1217 | 21303 | 1227 | 19883 | 1217 | 19352 | 1229 | 41187 | 1220 | 41593 | 1220 | 26217 |
| 1238 | 22014 | 1247 | 21871 | 1257 | 20390 | 1248 | 19858 | 1259 | 42247 | 1250 | 42679 | 1250 | 26905 |
| 1268 | 22589 | 1277 | 22446 | 1287 | 20895 | 1278 | 20363 | 1289 | 43303 | 1280 | 43764 | 1280 | 27596 |
| 1299 | 23168 | 1308 | 23021 | 1318 | 21398 | 1308 | 20866 | 1320 | 44347 | 1311 | 44852 | 1311 | 28288 |
| 1329 | 23745 | 1338 | 23595 | 1348 | 21900 | 1339 | 21367 | 1350 | 45379 | 1341 | 45943 | 1341 | 28976 |
| 1359 | 24320 | 1368 | 24170 | 1378 | 22402 | 1369 | 21867 | 1380 | 46401 | 1371 | 47042 | 1371 | 29663 |
| 1390 | 24891 | 1399 | 24743 | 1409 | 22904 | 1399 | 22366 | 1411 | 47405 | 1402 | 48137 | 1402 | 30345 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.15(Suit Seam M_f) + 0.05(Outer Zipper M_f) + 0.15(Hood Matl M_f) + 0.1(Crotch M_f) + 0.05(Zipper Matl Interface M_f)

Table H-2. ILC Dover Model 16-51 - Average GB Permeation

| ILC Dover Model 16-51 Coverall | | | | | | | | | | | | | |
|---|---------------|-------------|-----------|-------------|-----------------|-------------|--------------|-------------|---------------|-------------|--------|---------------------|-----------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Material | Time (min.) | Suit Seam | Time (min.) | Zipper Material | Time (min.) | Outer Zipper | Time (min.) | Hood Material | Time (min.) | Crotch | Average Time (min.) | Weighted Avg M _f |
| 6 | 1 | 15 | 4 | 5 | 1 | 14 | 4 | 12 | 0 | 3 | 1 | 9 | 1 |
| 36 | 11 | 45 | 21 | 35 | 188 | 44 | 204 | 42 | 96 | 33 | 26 | 39 | 45 |
| 67 | 216 | 76 | 232 | 65 | 611 | 74 | 517 | 72 | 399 | 63 | 290 | 70 | 288 |
| 97 | 591 | 106 | 641 | 95 | 1073 | 104 | 780 | 102 | 784 | 93 | 783 | 100 | 680 |
| 127 | 935 | 136 | 1048 | 125 | 1514 | 134 | 1100 | 132 | 1132 | 123 | 1273 | 130 | 1053 |
| 157 | 1273 | 167 | 1444 | 155 | 1948 | 164 | 1491 | 162 | 1464 | 153 | 1750 | 160 | 1420 |
| 188 | 1612 | 197 | 1834 | 185 | 2378 | 194 | 1932 | 192 | 1805 | 183 | 2220 | 190 | 1789 |
| 218 | 2005 | 227 | 2225 | 215 | 2808 | 224 | 2391 | 222 | 2172 | 213 | 2689 | 220 | 2191 |
| 248 | 2452 | 257 | 2645 | 245 | 3239 | 254 | 2854 | 252 | 2544 | 243 | 3148 | 250 | 2624 |
| 279 | 2901 | 288 | 3078 | 275 | 3669 | 284 | 3320 | 282 | 2912 | 273 | 3599 | 280 | 3058 |
| 309 | 3348 | 318 | 3511 | 305 | 4103 | 314 | 3795 | 312 | 3293 | 303 | 4050 | 310 | 3495 |
| 339 | 3797 | 348 | 3957 | 335 | 4548 | 344 | 4276 | 342 | 3691 | 333 | 4507 | 340 | 3938 |
| 370 | 4246 | 379 | 4403 | 365 | 5007 | 374 | 4762 | 372 | 4097 | 363 | 4974 | 371 | 4384 |
| 400 | 4695 | 409 | 4850 | 395 | 5472 | 404 | 5247 | 402 | 4513 | 393 | 5440 | 401 | 4832 |
| 430 | 5146 | 439 | 5298 | 425 | 5937 | 434 | 5733 | 432 | 4933 | 423 | 5901 | 431 | 5281 |
| 461 | 5596 | 470 | 5745 | 455 | 6409 | 464 | 6217 | 462 | 5358 | 453 | 6357 | 461 | 5730 |
| 491 | 6045 | 500 | 6191 | 485 | 6892 | 494 | 6700 | 492 | 5793 | 483 | 6820 | 491 | 6182 |
| 521 | 6493 | 530 | 6635 | 515 | 7378 | 524 | 7186 | 522 | 6236 | 513 | 7290 | 521 | 6634 |
| 551 | 6940 | 561 | 7079 | 545 | 7859 | 554 | 7673 | 552 | 6684 | 543 | 7762 | 551 | 7087 |
| 582 | 7385 | 591 | 7522 | 575 | 8341 | 584 | 8159 | 582 | 7136 | 573 | 8235 | 581 | 7540 |
| 612 | 7830 | 621 | 7966 | 605 | 8830 | 614 | 8647 | 612 | 7590 | 603 | 8707 | 611 | 7993 |
| 642 | 8276 | 651 | 8411 | 635 | 9325 | 644 | 9136 | 642 | 8046 | 633 | 9179 | 641 | 8448 |
| 673 | 8722 | 682 | 8854 | 665 | 9826 | 674 | 9626 | 672 | 8501 | 663 | 9651 | 672 | 8902 |
| 703 | 9169 | 712 | 9299 | 695 | 10336 | 704 | 10122 | 702 | 8956 | 693 | 10121 | 702 | 9358 |
| 733 | 9616 | 742 | 9744 | 725 | 10848 | 734 | 10630 | 732 | 9417 | 723 | 10590 | 732 | 9815 |
| 763 | 10063 | 773 | 10187 | 755 | 11369 | 764 | 11145 | 762 | 9883 | 753 | 11062 | 762 | 10274 |
| 794 | 10510 | 803 | 10630 | 785 | 11894 | 795 | 11656 | 792 | 10352 | 783 | 11539 | 792 | 10734 |
| 824 | 10958 | 833 | 11072 | 816 | 12421 | 825 | 12168 | 822 | 10824 | 813 | 12016 | 822 | 11194 |
| 854 | 11404 | 864 | 11514 | 846 | 12950 | 855 | 12682 | 852 | 11298 | 843 | 12491 | 852 | 11655 |
| 885 | 11850 | 894 | 11956 | 876 | 13480 | 885 | 13200 | 882 | 11771 | 873 | 12970 | 883 | 12115 |
| 915 | 12295 | 924 | 12397 | 906 | 14012 | 915 | 13723 | 912 | 12248 | 903 | 13450 | 913 | 12576 |
| 945 | 12741 | 955 | 12837 | 936 | 14548 | 945 | 14250 | 942 | 12725 | 933 | 13931 | 943 | 13038 |
| 976 | 13187 | 985 | 13277 | 967 | 15087 | 976 | 14775 | 972 | 13203 | 963 | 14412 | 973 | 13500 |
| 1006 | 13634 | 1015 | 13718 | 997 | 15625 | 1006 | 15304 | 1002 | 13684 | 993 | 14893 | 1003 | 13963 |
| 1036 | 14080 | 1046 | 14160 | 1027 | 16167 | 1036 | 15841 | 1032 | 14163 | 1023 | 15376 | 1033 | 14426 |
| 1067 | 14525 | 1076 | 14601 | 1057 | 16710 | 1066 | 16384 | 1062 | 14643 | 1053 | 15860 | 1064 | 14890 |
| 1097 | 14968 | 1106 | 15041 | 1088 | 17255 | 1097 | 16927 | 1092 | 15125 | 1083 | 16346 | 1094 | 15353 |
| 1127 | 15411 | 1137 | 15481 | 1118 | 17801 | 1127 | 17467 | 1122 | 15607 | 1113 | 16832 | 1124 | 15815 |
| 1158 | 15853 | 1167 | 15919 | 1148 | 18346 | 1157 | 18009 | 1152 | 16090 | 1143 | 17319 | 1154 | 16278 |
| 1188 | 16293 | 1197 | 16359 | 1178 | 18894 | 1187 | 18553 | 1182 | 16573 | 1173 | 17806 | 1184 | 16739 |
| 1218 | 16732 | 1228 | 16798 | 1208 | 19441 | 1218 | 19095 | 1212 | 17051 | 1203 | 18289 | 1215 | 17199 |
| 1249 | 17170 | 1258 | 17236 | 1239 | 19988 | 1248 | 19638 | 1242 | 17525 | 1233 | 18769 | 1245 | 17657 |
| 1279 | 17605 | 1288 | 17674 | 1269 | 20536 | 1278 | 20184 | 1272 | 17998 | 1263 | 19249 | 1275 | 18114 |
| 1309 | 18038 | 1319 | 18111 | 1299 | 21083 | 1308 | 20729 | 1302 | 18469 | 1293 | 19731 | 1305 | 18570 |
| 1340 | 18469 | 1349 | 18546 | 1329 | 21626 | 1338 | 21266 | 1332 | 18936 | 1323 | 20211 | 1335 | 19023 |
| 1370 | 18897 | 1379 | 18981 | 1360 | 22166 | 1369 | 21804 | 1362 | 19401 | 1353 | 20690 | 1366 | 19473 |
| 1400 | 19322 | 1410 | 19413 | 1390 | 22705 | 1399 | 22339 | 1392 | 19864 | 1383 | 21171 | 1396 | 19922 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.15(Suit Seam M_f) + 0.05(Outer Zipper M_f) + 0.15(Hood Matl M_f) + 0.1(Crotch M_f) + 0.05(Zipper Matl Interface M_f)

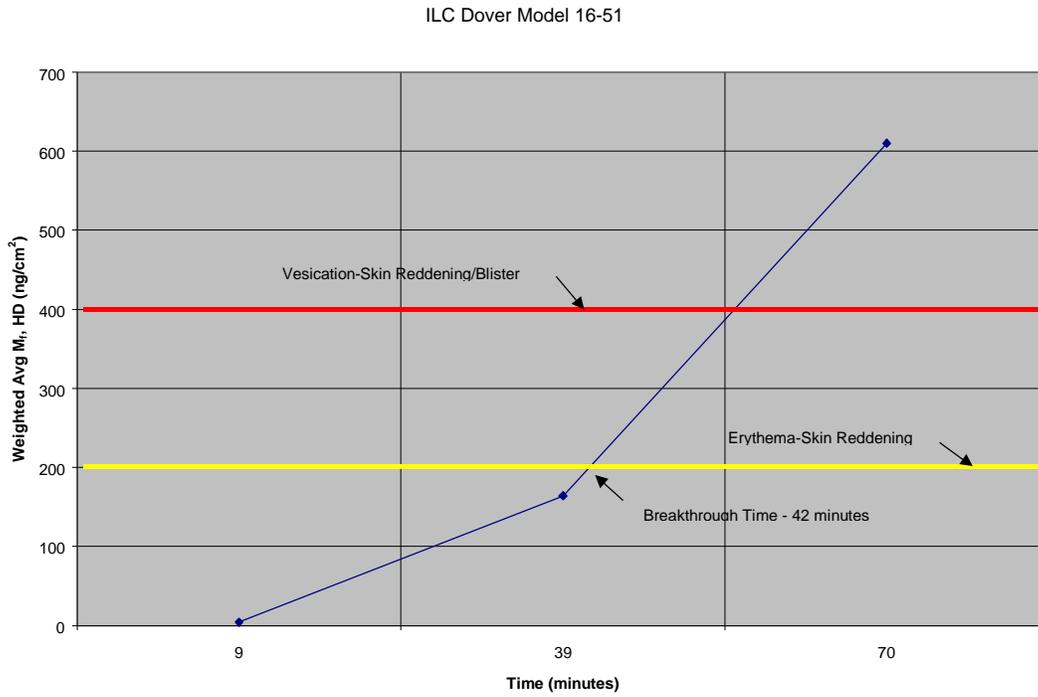


Figure H-3: ILC Dover Model 16-51 - Weighted Average HD Permeation

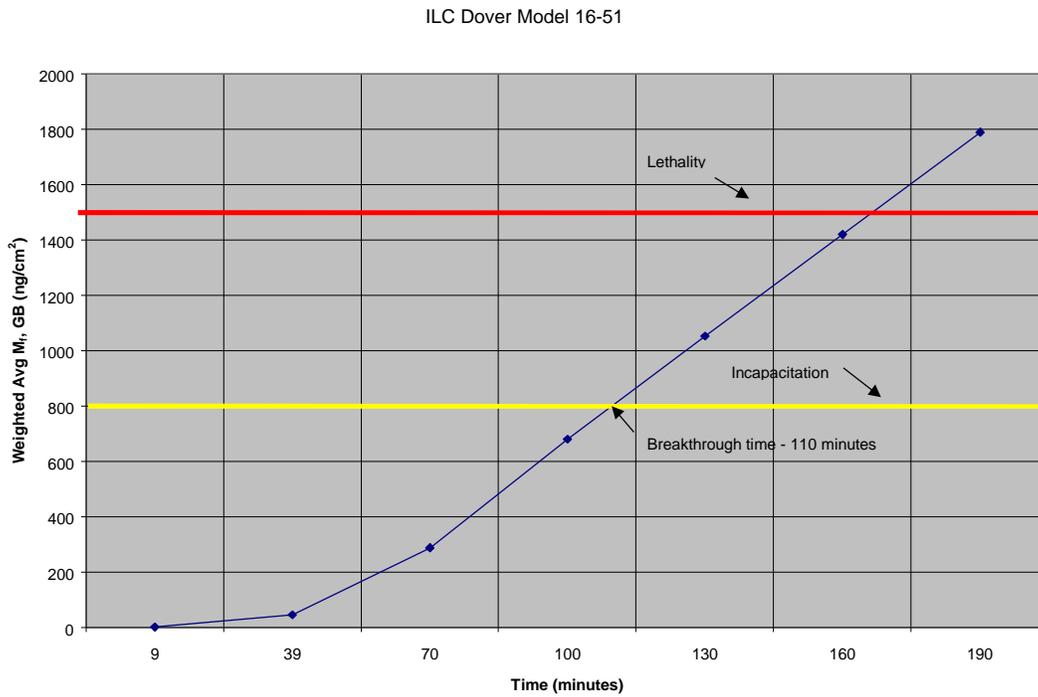


Figure H-4: ILC Dover Model 16-51 - Weighted Average GB Permeation

ILC Dover Model 16-51

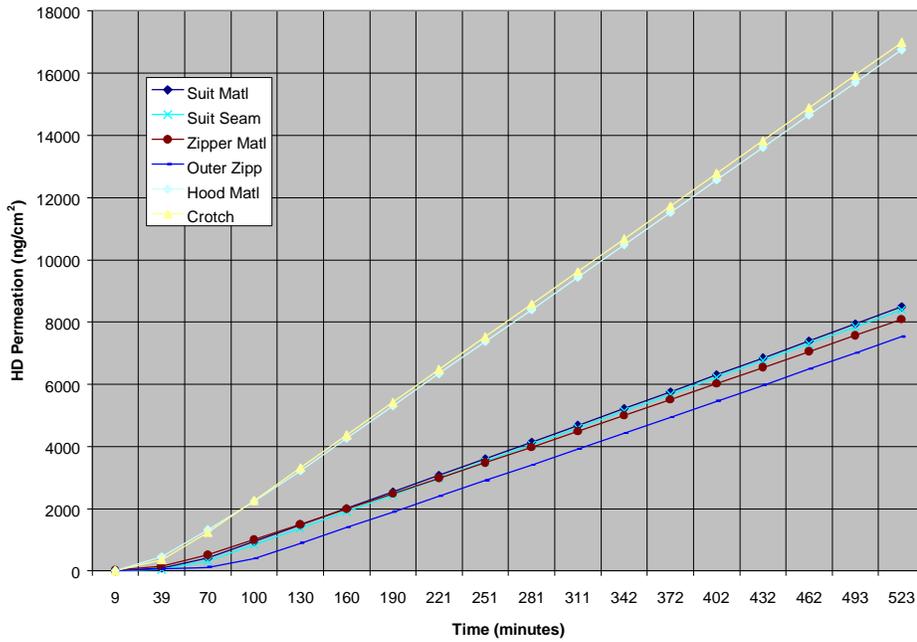


Figure H-5: ILC Dover Model 16-51: HD Permeation by Sampling Area

ILC Dover Model 16-51

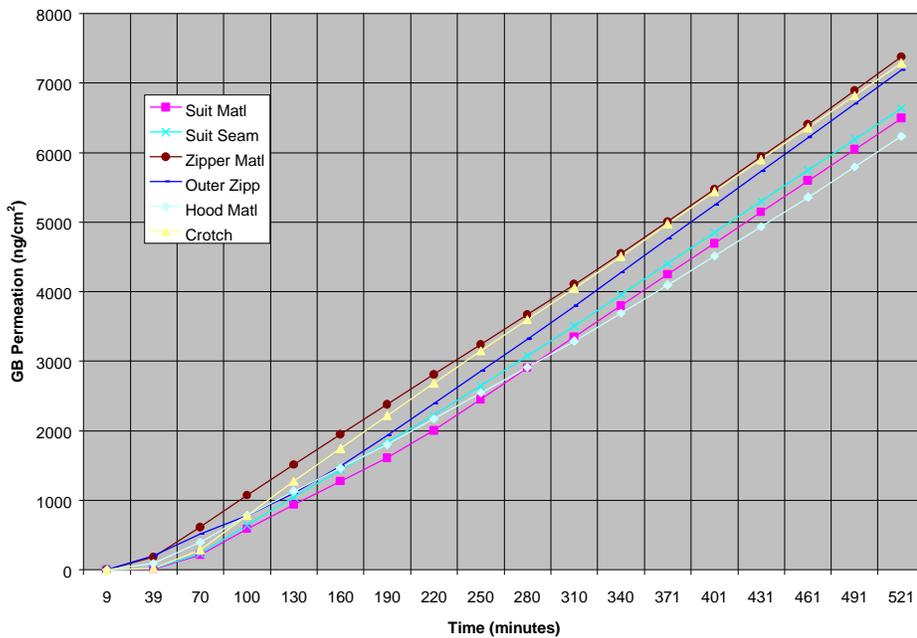


Figure H-6: ILC Dover Model 16-51: GB Permeation by Sampling Area

Table H-3. ILC Dover Model 16-51 - System Test (Aerosol Simulant) Results

| PF Range | Visor Region and Upper Arm, Combined | | | | | |
|---------------|--------------------------------------|--------------------------|-------------------------------|---------------------------|--------------------------|-------------------------------|
| | Pre-Operational Exercises | | | Operational Exercises | | |
| | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent |
| 0-9 | 24 | 100 | 0 | 24 | 100 | 0 |
| 10-49 | 0 | 100 | 0 | 0 | 100 | 0 |
| 50-99 | 0 | 100 | 0 | 0 | 100 | 0 |
| 100-499 | 0 | 100 | 0 | 0 | 100 | 0 |
| 500-999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 1000-1666 | 0 | 100 | 0 | 0 | 100 | 0 |
| 1667-4999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 5000-6666 | 0 | 100 | 0 | 0 | 100 | 0 |
| 6667-9999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 10000-19999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 20000-49999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 50000-99999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 100000+ | 0 | 100 | 0 | 0 | 100 | 0 |
| No. of Trials | 24 | | | 24 | | |

Table H-4. ILC Dover Model 16-51 - Overall Test Results

| Breakthrough Time (minutes) | | Aerosol PF Pass Rate at PF Equal to: | | | Exercise Phase |
|-----------------------------|----------|--------------------------------------|-----|-----|-----------------|
| Incapacitation | Erythema | 10 | 50 | 100 | |
| GB | HD | | | | |
| 110 | 42 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | 0.0 | 0.0 | 0.0 | Operational |



**Figure I-1: Trelleborg Splash 700 – 1 Piece Suit –
Front View**



**Figure I-2: Trelleborg Splash 700 – 1 Piece Suit-
Side View**

Table I-1. Trelleborg Splash 700 - Average HD Permeation

| Trelleborg Splash 700 – 1 Piece Suit | | | | | | | | | | | | | |
|---|---------------|-------------|-----------|-------------|-----------------|-------------|-------------------|-------------|----------------|-------------|-----------------------|---------------------|-----------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Material | Time (min.) | Suit Seam | Time (min.) | Zipper Material | Time (min.) | Visor/Gasket Seam | Time (min.) | Glove Material | Time (min.) | Visor/Gasket Material | Average Time (min.) | Weighted Avg M _f |
| 5 | 0 | 14 | 2 | 14 | 0 | 14 | 3 | 5 | 0 | 14 | 3 | 11 | 1 |
| 35 | 130 | 44 | 42 | 44 | 24 | 44 | 15 | 35 | 0 | 44 | 15 | 41 | 75 |
| 65 | 1405 | 74 | 1202 | 74 | 914 | 74 | 33 | 65 | 0 | 74 | 33 | 71 | 933 |
| 95 | 3681 | 104 | 2699 | 104 | 2681 | 104 | 89 | 95 | 9 | 104 | 89 | 101 | 2394 |
| 125 | 5954 | 134 | 3450 | 134 | 4496 | 134 | 261 | 125 | 40 | 134 | 261 | 131 | 3764 |
| 155 | 8241 | 164 | 4204 | 164 | 6329 | 164 | 691 | 155 | 126 | 164 | 691 | 161 | 5190 |
| 185 | 10525 | 194 | 5331 | 194 | 8180 | 194 | 1441 | 185 | 346 | 194 | 1441 | 191 | 6739 |
| 215 | 12801 | 224 | 6460 | 224 | 10040 | 224 | 2418 | 215 | 805 | 224 | 2418 | 221 | 8355 |
| 245 | 15069 | 254 | 7217 | 254 | 11891 | 254 | 3476 | 245 | 1587 | 254 | 3476 | 251 | 9971 |
| 275 | 16954 | 284 | 7974 | 284 | 13734 | 284 | 4508 | 275 | 2716 | 284 | 4508 | 281 | 11443 |
| 305 | 18457 | 314 | 8738 | 314 | 15573 | 314 | 5478 | 305 | 4130 | 314 | 5478 | 311 | 12759 |
| 335 | 19968 | 344 | 9511 | 344 | 17409 | 344 | 6389 | 335 | 5724 | 344 | 6389 | 341 | 14098 |
| 365 | 21081 | 374 | 10287 | 374 | 19247 | 374 | 7261 | 365 | 7412 | 374 | 7261 | 371 | 15247 |
| 395 | 22183 | 404 | 11438 | 404 | 21061 | 404 | 8109 | 395 | 9122 | 404 | 8109 | 401 | 16445 |
| 425 | 23669 | 434 | 12960 | 434 | 22853 | 434 | 8944 | 425 | 10841 | 434 | 8944 | 431 | 17889 |
| 455 | 25150 | 464 | 14870 | 464 | 24646 | 464 | 9777 | 455 | 12573 | 464 | 9777 | 461 | 19390 |
| 485 | 27026 | 494 | 17179 | 494 | 26438 | 494 | 10671 | 485 | 14313 | 494 | 10671 | 491 | 21159 |
| 515 | 28938 | 524 | 19491 | 524 | 28235 | 524 | 11664 | 515 | 16069 | 524 | 11664 | 521 | 22964 |
| 545 | 30486 | 554 | 21791 | 554 | 30030 | 554 | 12752 | 545 | 17823 | 554 | 12752 | 551 | 24599 |
| 575 | 32040 | 584 | 24108 | 584 | 31821 | 584 | 13940 | 575 | 19580 | 584 | 13940 | 581 | 26255 |
| 605 | 33966 | 614 | 26457 | 614 | 33611 | 614 | 15205 | 605 | 21344 | 614 | 15205 | 611 | 28114 |
| 635 | 36252 | 644 | 28810 | 644 | 35402 | 644 | 16555 | 635 | 23113 | 644 | 16555 | 641 | 30168 |
| 665 | 38533 | 674 | 31160 | 674 | 37195 | 674 | 17973 | 665 | 24885 | 674 | 17973 | 671 | 32229 |
| 695 | 40809 | 704 | 33514 | 704 | 38990 | 704 | 19437 | 695 | 26662 | 704 | 19437 | 701 | 34296 |
| 725 | 43077 | 734 | 35861 | 734 | 40785 | 734 | 20952 | 725 | 28438 | 734 | 20952 | 731 | 36365 |
| 755 | 45333 | 764 | 38204 | 764 | 42577 | 764 | 22507 | 755 | 30215 | 764 | 22507 | 761 | 38434 |
| 785 | 47576 | 794 | 40540 | 794 | 44370 | 794 | 24084 | 785 | 31998 | 794 | 24084 | 791 | 40500 |
| 815 | 49796 | 824 | 42870 | 824 | 46162 | 824 | 25518 | 815 | 33779 | 824 | 25518 | 821 | 42531 |
| 845 | 51994 | 854 | 45187 | 854 | 47952 | 854 | 26757 | 845 | 35558 | 854 | 26757 | 851 | 44520 |
| 875 | 54175 | 884 | 47497 | 884 | 49741 | 884 | 27735 | 875 | 37340 | 884 | 27735 | 881 | 46460 |
| 905 | 56328 | 914 | 49803 | 914 | 51529 | 914 | 28654 | 905 | 39123 | 914 | 28654 | 911 | 48377 |
| 935 | 58461 | 944 | 52104 | 944 | 53317 | 944 | 29590 | 935 | 40903 | 944 | 29590 | 941 | 50286 |
| 965 | 60577 | 974 | 54402 | 974 | 55105 | 974 | 30540 | 965 | 42689 | 974 | 30540 | 971 | 52188 |
| 995 | 62661 | 1004 | 56685 | 1004 | 56890 | 1004 | 31499 | 995 | 44471 | 1004 | 31499 | 1001 | 54073 |
| 1025 | 64723 | 1034 | 58959 | 1034 | 58672 | 1034 | 32474 | 1025 | 46244 | 1034 | 32474 | 1031 | 55947 |
| 1055 | 66767 | 1064 | 61232 | 1064 | 60455 | 1064 | 33458 | 1055 | 48012 | 1064 | 33458 | 1061 | 57812 |
| 1085 | 68785 | 1094 | 63500 | 1094 | 62254 | 1094 | 34443 | 1085 | 49791 | 1094 | 34443 | 1091 | 59665 |
| 1115 | 70773 | 1124 | 65764 | 1124 | 64063 | 1124 | 35434 | 1115 | 51589 | 1124 | 35434 | 1121 | 61508 |
| 1145 | 72729 | 1154 | 68016 | 1154 | 65864 | 1154 | 36436 | 1145 | 53393 | 1154 | 36436 | 1151 | 63334 |
| 1175 | 74661 | 1184 | 70256 | 1184 | 67660 | 1184 | 37448 | 1175 | 55181 | 1184 | 37448 | 1181 | 65146 |
| 1205 | 76561 | 1214 | 72485 | 1214 | 69454 | 1214 | 38456 | 1205 | 56964 | 1214 | 38456 | 1211 | 66939 |
| 1235 | 78428 | 1244 | 74698 | 1244 | 71244 | 1244 | 39456 | 1235 | 58754 | 1244 | 39456 | 1241 | 68712 |
| 1265 | 80268 | 1274 | 76900 | 1274 | 73039 | 1274 | 40462 | 1265 | 60550 | 1274 | 40462 | 1271 | 70473 |
| 1295 | 82070 | 1304 | 79087 | 1304 | 74841 | 1304 | 41480 | 1295 | 62351 | 1304 | 41480 | 1301 | 72215 |
| 1325 | 83822 | 1334 | 81246 | 1334 | 76640 | 1334 | 42508 | 1325 | 64147 | 1334 | 42508 | 1331 | 73928 |
| 1355 | 85479 | 1364 | 83310 | 1364 | 78438 | 1364 | 43548 | 1355 | 65943 | 1364 | 43548 | 1361 | 75582 |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: Wtd Avg M_f = 0.5(Suit Matl M_f) + 0.15(Suit Seam M_f) + 0.05(Visor/Gasket Seam M_f) + 0.15(Glove Matl M_f) + 0.1(Visor/Gasket Matl M_f) + 0.05(Zipper Matl Interface M_f)

Table I-2. Trelleborg Splash 700 - Average GB Permeation

| Trelleborg Splash 700 – 1 Piece Suit | | | | | | | | | | | | | |
|---|------------|-------------|-----------|-------------|--------------|-------------|-------------------|-------------|-------------|-------------|-----------------------|---------------------|------------------------------|
| M _f , Average Permeation (ng/cm ²) | | | | | | | | | | | | | |
| Time (min.) | Suit Mat'l | Time (min.) | Suit Seam | Time (min.) | Zipper Mat'l | Time (min.) | Visor/Gasket Seam | Time (min.) | Glove Mat'l | Time (min.) | Visor/Gasket Material | Average Time (min.) | Weighted Avg. M _f |
| 5 | 0 | 14 | 1 | 4 | 1 | 14 | 1 | 13 | 1 | 5 | 0 | 9 | 0 |
| 36 | 813 | 45 | 316 | 35 | 101 | 44 | 565 | 44 | 15 | 35 | 0 | 40 | 489 |
| 66 | 3188 | 75 | 2155 | 65 | 806 | 74 | 1692 | 74 | 155 | 65 | 15 | 70 | 2067 |
| 96 | 6341 | 105 | 5295 | 95 | 2446 | 104 | 2863 | 104 | 517 | 95 | 347 | 100 | 4342 |
| 127 | 9541 | 136 | 8544 | 126 | 4605 | 134 | 4185 | 135 | 1012 | 125 | 1648 | 131 | 6808 |
| 157 | 12766 | 166 | 11791 | 156 | 6867 | 164 | 5712 | 165 | 2000 | 155 | 4075 | 161 | 9488 |
| 187 | 15982 | 196 | 15022 | 186 | 9138 | 194 | 7402 | 195 | 3547 | 185 | 7170 | 191 | 12320 |
| 218 | 19180 | 227 | 18250 | 217 | 11408 | 224 | 9253 | 226 | 5304 | 215 | 10472 | 221 | 15203 |
| 248 | 22383 | 257 | 21465 | 247 | 13669 | 254 | 11299 | 256 | 7292 | 245 | 13779 | 251 | 18131 |
| 278 | 25581 | 287 | 24665 | 277 | 15925 | 284 | 13509 | 286 | 9444 | 275 | 17092 | 281 | 21088 |
| 309 | 28770 | 318 | 27856 | 308 | 18181 | 314 | 15840 | 317 | 11748 | 305 | 20396 | 312 | 24066 |
| 339 | 31959 | 348 | 31040 | 338 | 20363 | 344 | 18276 | 347 | 14141 | 335 | 23695 | 342 | 27058 |
| 369 | 35151 | 378 | 34207 | 368 | 22495 | 374 | 20802 | 377 | 16526 | 365 | 26991 | 372 | 30049 |
| 400 | 38322 | 409 | 37351 | 399 | 24663 | 404 | 23394 | 408 | 18907 | 395 | 30276 | 403 | 33030 |
| 430 | 41418 | 439 | 40445 | 429 | 26842 | 434 | 26029 | 438 | 21287 | 425 | 33543 | 433 | 35967 |
| 460 | 44455 | 469 | 43489 | 459 | 29028 | 464 | 28708 | 468 | 23666 | 455 | 36799 | 463 | 38867 |
| 491 | 47477 | 500 | 46518 | 490 | 31198 | 494 | 31421 | 499 | 26043 | 485 | 40053 | 493 | 41759 |
| 521 | 50486 | 530 | 49533 | 520 | 33379 | 524 | 34160 | 529 | 28436 | 515 | 43315 | 523 | 44647 |
| 551 | 53492 | 560 | 52542 | 550 | 35566 | 554 | 36922 | 559 | 30829 | 545 | 46580 | 553 | 47534 |
| 582 | 56508 | 591 | 55560 | 581 | 37729 | 584 | 39739 | 590 | 33199 | 575 | 49857 | 584 | 50427 |
| 612 | 59533 | 621 | 58578 | 611 | 39892 | 614 | 42648 | 620 | 35565 | 605 | 53181 | 614 | 53333 |
| 642 | 62559 | 651 | 61596 | 641 | 42059 | 644 | 45667 | 650 | 37937 | 635 | 56531 | 644 | 56249 |
| 673 | 65576 | 682 | 64603 | 672 | 44232 | 674 | 48771 | 681 | 40307 | 665 | 59866 | 675 | 59161 |
| 703 | 68579 | 712 | 67600 | 702 | 46410 | 704 | 51900 | 711 | 42673 | 695 | 63175 | 705 | 62063 |
| 733 | 71585 | 742 | 70597 | 732 | 48593 | 734 | 55038 | 741 | 45045 | 725 | 66455 | 735 | 64966 |
| 764 | 74597 | 773 | 73591 | 763 | 50752 | 764 | 58156 | 772 | 47423 | 755 | 69704 | 765 | 67866 |
| 794 | 77613 | 803 | 76580 | 793 | 52903 | 794 | 61235 | 802 | 49809 | 785 | 72924 | 795 | 70764 |
| 824 | 80624 | 833 | 79560 | 823 | 55064 | 824 | 64280 | 832 | 52207 | 815 | 76126 | 825 | 73657 |
| 855 | 83625 | 864 | 82531 | 854 | 57226 | 854 | 67286 | 863 | 54606 | 845 | 79313 | 856 | 76540 |
| 885 | 86618 | 894 | 85491 | 884 | 59403 | 884 | 70238 | 893 | 57000 | 875 | 82489 | 886 | 79414 |
| 915 | 89596 | 924 | 88433 | 914 | 61582 | 914 | 73122 | 923 | 59401 | 905 | 85662 | 916 | 82275 |
| 946 | 92559 | 955 | 91368 | 945 | 63757 | 944 | 75933 | 954 | 61798 | 935 | 88823 | 947 | 85121 |
| 976 | 95508 | 985 | 94289 | 975 | 65931 | 974 | 78681 | 984 | 64190 | 965 | 91967 | 977 | 87953 |
| 1006 | 98440 | 1015 | 97188 | 1005 | 68103 | 1004 | 81373 | 1014 | 66576 | 995 | 95091 | 1007 | 90768 |
| | | 1040 | 99491 | 1036 | 70271 | | | 1045 | 68962 | | | 1040 | |
| | | 1064 | 101773 | 1066 | 72433 | | | 1075 | 71345 | | | 1068 | |
| | | | | 1096 | 74586 | | | 1105 | 73719 | | | 1101 | |
| | | | | 1127 | 76728 | | | 1136 | 76095 | | | 1132 | |
| | | | | 1157 | 78870 | | | 1166 | 78472 | | | 1162 | |
| | | | | 1187 | 80867 | | | 1196 | 80837 | | | 1192 | |
| | | | | 1218 | 82711 | | | 1227 | 83183 | | | 1223 | |
| | | | | 1248 | 84546 | | | 1257 | 85500 | | | 1253 | |
| | | | | 1278 | 86367 | | | 1287 | 87802 | | | 1283 | |
| | | | | 1309 | 88135 | | | 1318 | 90121 | | | 1314 | |
| | | | | 1339 | 89898 | | | | | | | 1339 | |
| | | | | 1366 | 91439 | | | | | | | 1366 | |
| | | | | 1393 | 92893 | | | | | | | 1393 | |
| | | | | 1421 | 94359 | | | | | | | | |

Note 1: The time given for each sampling area is the average of the elapsed times for the three swatches tested per sampling area.

Note 2: The avg. time is the sum of the times given for each sampling area divided by the number of sampling areas.

Note 3: $Wtd\ Avg\ M_f = 0.5(Suit\ Mat'l\ M_f) + 0.15(Suit\ Seam\ M_f) + 0.05(Visor/Gasket\ Seam\ M_f) + 0.15(Glove\ Mat'l\ M_f) + 0.1(Visor/Gasket\ Mat'l\ M_f) + 0.05(Zipper\ Mat'l\ Interface\ M_f)$

Note 4: The MINICAMS permeation software has an upper cumulative permeation limit of 100000 ng/cm². Many of the Splash 700 swatches reached this limit at roughly 1000 minutes and were no longer sampled by the MINICAMS. It was not possible to calculate meaningful averages after that point. For the sampling areas, M_f is only shown where all 3 swatches were still being sampled.

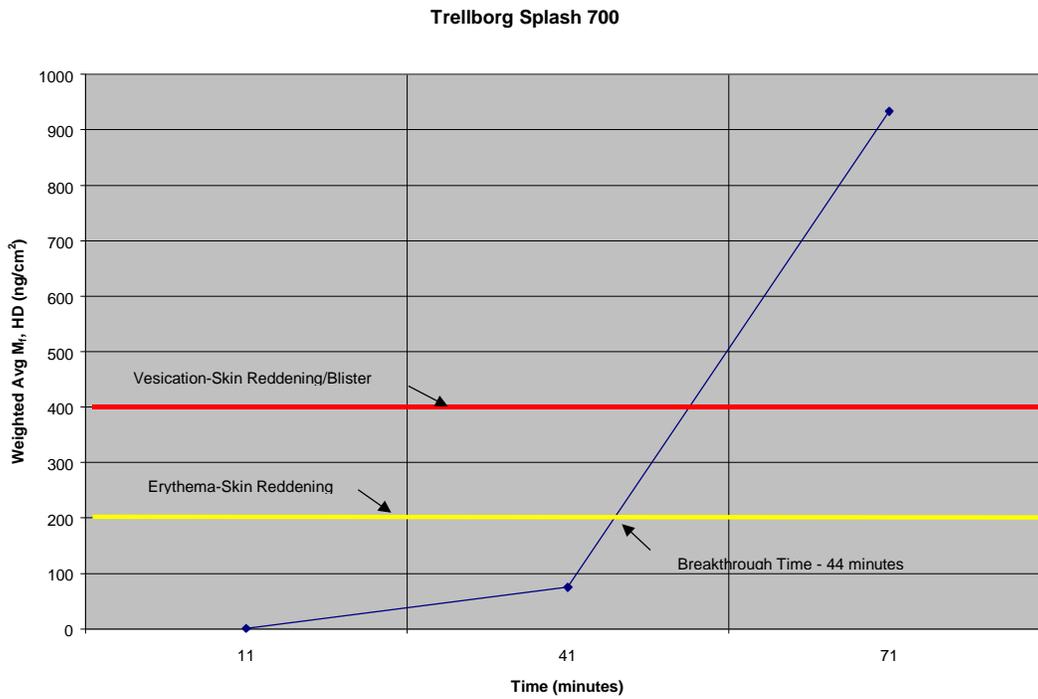


Figure I-3: Trelleborg Splash 700 – 1 Piece Suit - Weighted Average HD Permeation

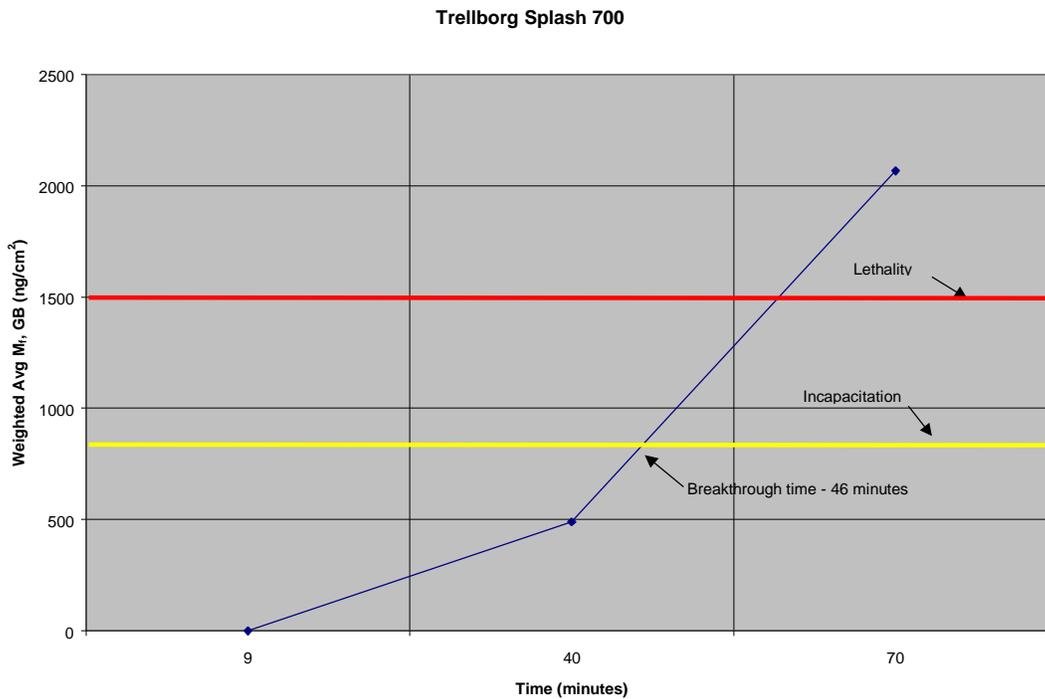


Figure I-4: Trelleborg Splash 700 – 1 Piece Suit - Weighted Average GB Permeation

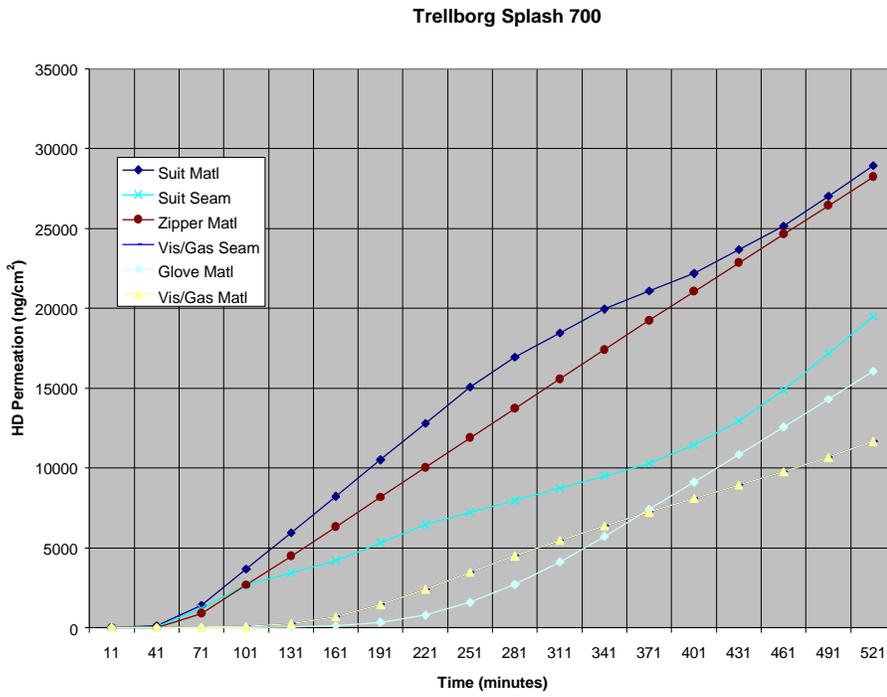


Figure I-5: Trelleborg Splash 700 – 1 Piece Suit: HD Permeation by Sampling Area

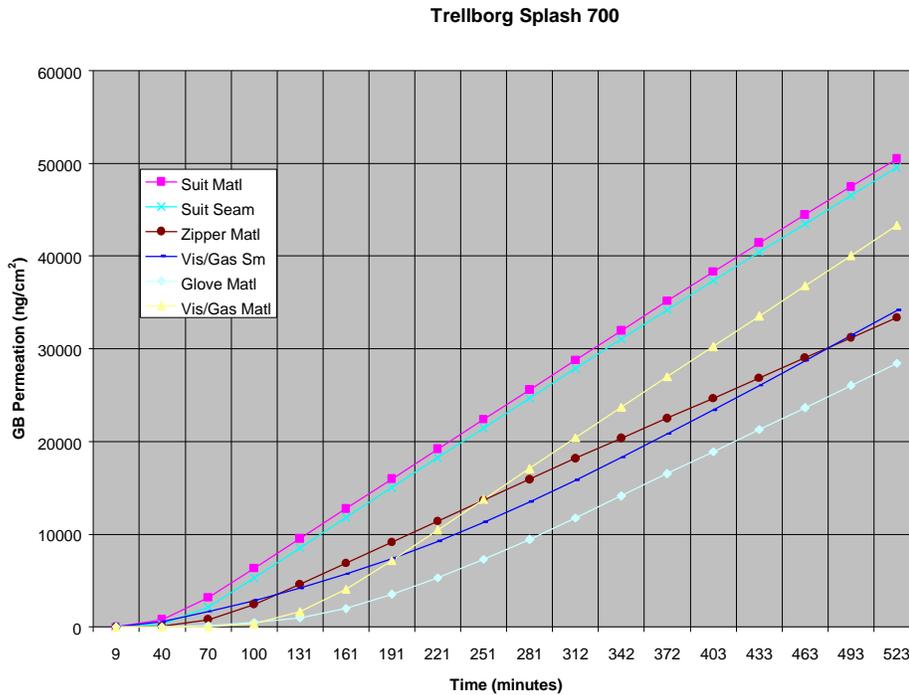


Figure I-6: Trelleborg Splash 700 – 1 Piece Suit: GB Permeation by Sampling Area

Table I-3: Trelleborg Splash 700 – 1 Piece Suit- System Test (Aerosol Simulant) Results

| PF Range | Visor Region and Upper Arm, Combined | | | | | |
|---------------|--------------------------------------|--------------------------|-------------------------------|---------------------------|--------------------------|-------------------------------|
| | Pre-Operational Exercises | | | Operational Exercises | | |
| | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent | No. of Occasions in Range | Cumulative Rate, Percent | Cumulative Pass Rate, Percent |
| 0-9 | 14 | 58.3 | 41.7 | 20 | 83.3 | 16.7 |
| 10-49 | 10 | 100 | 0 | 4 | 100 | 0 |
| 50-99 | 0 | 100 | 0 | 0 | 100 | 0 |
| 100-499 | 0 | 100 | 0 | 0 | 100 | 0 |
| 500-999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 1000-1666 | 0 | 100 | 0 | 0 | 100 | 0 |
| 1667-4999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 5000-6666 | 0 | 100 | 0 | 0 | 100 | 0 |
| 6667-9999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 10000-19999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 20000-49999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 50000-99999 | 0 | 100 | 0 | 0 | 100 | 0 |
| 100000+ | 0 | 100 | 0 | 0 | 100 | 0 |
| No. of Trials | 24 | | | 24 | | |

Table I-4. Trelleborg Splash 700 – 1 Piece Suit- Overall Test Results

| Breakthrough Time (minutes) | | Aerosol PF Pass Rate at PF Equal to: | | | Exercise Phase |
|-----------------------------|----------|--------------------------------------|-----|-----|-----------------|
| Incapacitation | Erythema | 10 | 50 | 100 | |
| GB | HD | | | | |
| 46 | 44 | 41.7 | 0.0 | 0.0 | Pre-Operational |
| | | 16.7 | 0.0 | 0.0 | Operational |

Summary of HD Permeation Results

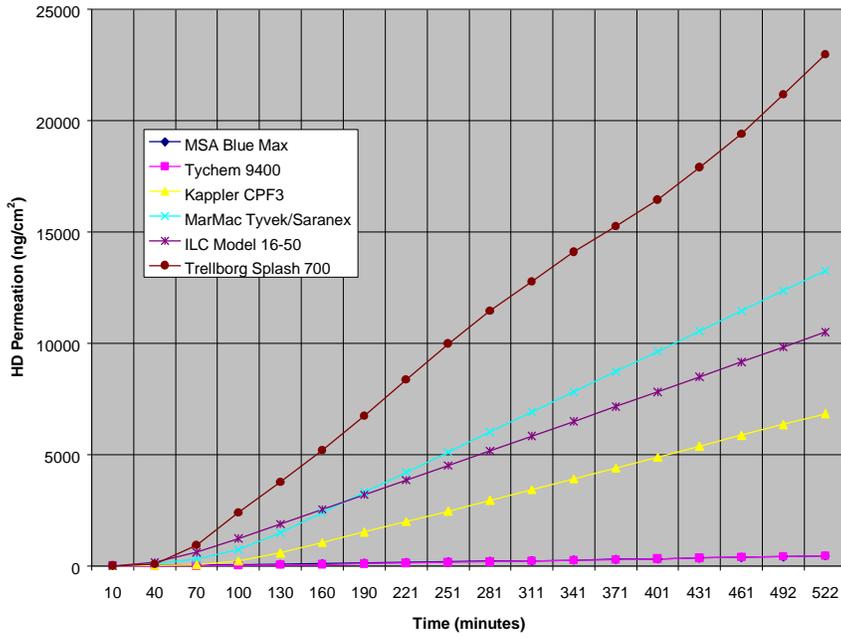


Figure J-1: Weighted Average HD Permeation

Summary of GB Permeation Results

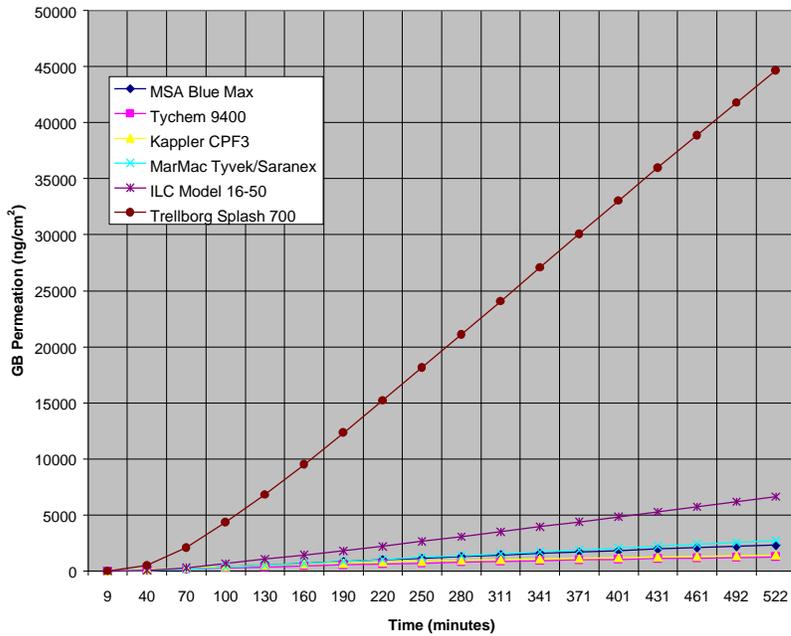


Figure J-2: Weighted Average GB Permeation

Table J-1. Summary of Overall Results for all Level B Suits

| Test Item | Breakthrough Time (minutes) | | Aerosol PF Pass Rate at PF Equal | | | Exercise Phase |
|--|-----------------------------|----------|----------------------------------|-----|-----|-----------------|
| | Incapacitation | Erythema | to: | | | |
| | GB | HD | 10 | 50 | 100 | |
| MSA Blue Max Model B | 181 | 275 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | | 0.0 | 0.0 | 0.0 | Operational |
| LakelandTychem 9400 Coverall - 91450 | 290 | 298 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | | 0.0 | 0.0 | 0.0 | Operational |
| Kappler CPF3 Coverall 3T436 | 220 | 97 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | | 0.0 | 0.0 | 0.0 | Operational |
| MarMac Tyvek /Saranex 23-P Coverall | 178 | 54 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | | 0.0 | 0.0 | 0.0 | Operational |
| ILC Dover Model 16-51 Coverall | 110 | 42 | 0.0 | 0.0 | 0.0 | Pre-Operational |
| | | | 0.0 | 0.0 | 0.0 | Operational |
| Trelleborg Splash 700 – 1 Piece Suit | 46 | 44 | 41.7 | 0.0 | 0.0 | Pre-Operational |
| | | | 16.7 | 0.0 | 0.0 | Operational |